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Tiled Raster Graphics and MIL-R-28002A: A Tutorial and Implementation Guide

Frankie E. Spielman
Louis H. Sharpe, II

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National Institute of Standards and Technology
Computer Systems Laboratory
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Abstract

This report examines the technical issues facing an implementor of the raster data interchange format defined in military specification MIL-R-28002A. Information previously scattered throughout several standards is incorporated into this report for ease of reference. The National Institute of Standards and Technology Office Document Architecture Raster Document Application Profile (NIST ODA Raster DAP) is analyzed with regard to both notation and intent.

Keywords

Abstract Syntax Notation One, ASN.1, CALS, DAP, document application profile, image compression, image encoding, image interchange, ODA, Office Document Architecture, raster, tiled raster data.

PREFACE

The history and motivations behind the development of the raster graphics file formats for large documents which are detailed in the MIL-R-28002A specification [15] are interesting and have been detailed elsewhere [18].

The Computer-aided Acquisition and Logistic Support (CALS) Office of the Department of Defense asked the large document raster industry to provide suggestions for a standard interchange file format and raster encoding scheme. The result was formation of an ad-hoc industry group known as the Tiling Task Group (TTG) which quickly completed work on a draft standard based on the Consultative Committee on Telegraphy and Telephony (CCITT) Recommendation T.73.

The TTG soon discovered that subsequent to approval of T.73 CCITT had been collaborating with the International Organization for Standardization (ISO) and was developing a technology based upon the concept of a compound document which was to replace the current facsimile environment. International Standard (IS) 8613, which defines the Office Document Architecture (ODA), was the result. It fills two important needs: (1) storing complex documents containing graphics and textual information in complex word processors, and (2) allowing facsimile technology to produce true compound documents which are more than just hard copy.

The TTG modified its file format into a Document Application Profile (DAP) for ODA and wrote a proposed addendum to IS 8613, Part 7, in order to insert the minimal mechanisms needed to support tiling. DAPs are developed by groups such as the TTG to satisfy special user requirements.

MIL-R-28002A references this standardization effort as its Type II raster file format. The DAP continues to be further developed through the efforts of the Open Systems Interconnection (OSI) Implementors Workshop. This report will therefore need to be revised upon completion of the DAP standardization effort.

MIL-R-28002A also defines a Type I file format. It is based on a single monolithic block of compressed data and reflects a similar practice in the earlier Army (DSREDS) and Air Force (EDCARS) contracts.

Acknowledgements

Many people contributed to the creation of this report. All the members of the Tiling Task Group originated and reviewed many of the ideas in this document and anticipated the problems implementors might have. Marcel Rivard, Christian Kunz, Bancroft Scott, Peter Sih, and several members of the ODA Special Interest Group brought to light and analyzed some difficult areas of ODA or ASN.1 interpretation. Nick Mitschowetz created the tiled test image which is used in the examples. Joe Farrington helped analyze that document with the use of the NIST Free Value tool. Joe Garner, Jack Jeffers, Phil Battey, and Bob Moyer made particularly close readings of multiple drafts of this report. Jim Dalgety worked hard to see that this document came to be at all.

The efforts of many other people too numerous to mention are gratefully acknowledged.

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1 INTRODUCTION

The purpose of this tutorial is to give informal guidance and hints to those undertaking implementations of military specification MIL-R-28002A. The intended audience is therefore system architects and programmers.

First, this tutorial provides an overview of the pertinent standards primarily focusing on MIL-R-28002A (section 2), a discussion on the benefits of Office Document Architecture (ODA) (section 3), and an overview of ODA (section 4). This is followed by a discussion of the organizations involved with ODA and raster graphics (section 5).

The tutorial examines the actual sequence of data elements found in a raster graphics file (section 6). This then leads into a detailed description of the ODA structure and its elements (section 7) and the document application profile (section 8).

It then explains the coding concepts used for the ODA interchange format. These are based upon the abstract syntax notation and basic encoding rules (section 9).

In the latter portion of this document, the details of several technical concepts are explained (section 10). It then briefly discusses some tools that may be used by implementors (section 11) and provides a glossary (section 12) and a list of references (section 13).

Appendix A provides a complete list of the abstract syntax notation definitions representing an implementation of the document application profile.

The remaining appendices (B-E) provide a test chart image in both data value and transfer value form.

This document is intended to be an aid to an implementor of MIL-R-28002A and the requisite standards referenced in it. The guidance provided in this tutorial is for information only. In cases of technical errors or conflicts with the referenced standards, the standards will prevail.

2 PERTINENT STANDARDS

There are two military documents, Military Standard MIL-STD-1840 and Military Specification MIL-R-28002A, which are the basis for this tutorial. In turn, these documents reference other pertinent International Organization for Standardization (ISO) and Federal Information Processing Standards (FIPS) standards.

2.1 MIL-STD-1840

MIL-STD-1840, Military Standard, Automated Interchange of Technical Information [16], standardizes the format and structure of digital technical data files for the purpose of interchange between organizations or systems. For raster files, it describes a file header to be placed ahead of any raster data specified by MIL-R-28002A. One of the motivations behind its creation was the need to capture the Hollerith information from aperture cards and deliver it along with the scanned raster data on magnetic tape or other media.

2.2 MIL-R-28002A

MIL-R-28002A, Military Specification, Requirements for Raster Graphics Representation in Binary Format [15], defines the structure and encoding of raster data files to be delivered to the government. It was created with the storage and interchange of scanned engineering drawings in mind, but applies to other documents as well, such as technical manuals and illustrations in raster form. MIL-R-28002A can also serve as a means for standard interchange between private contractors.

Some features of the NIST ODA Raster Document Application Profile (DAP) are further restricted by statements in MIL-R-28002A, either because generality was desired in the DAP or because the mechanisms for these specific kinds of limitations are not available within ODA (see **NIST ODA Raster DAP**, paragraph 2.3).

Contracting Options

There is a variety of parameters that are free to vary while still remaining within the bounds of MIL-R-28002A. These items are separated into two classes:

1. Those that must be specified by the contracting officer in order to avoid ambiguity or incorrect implementations, and

2. Those that a contracting officer may wish to specify, but which, in the absence of compelling reasons to do so, are better left to the implementor's judgement.

Some issues within MIL-R-28002A requiring additional clarification are discussed in the **Technical Concepts** section of this tutorial.

Type I and Type II Data

MIL-R-28002A discusses two different possible representations of raster data: Type I and Type II.

Type I data is simply CCITT T.6 encoded data for an entire scan representation enclosed within MIL-STD-1840 header information. The CCITT T.6 encoding of raster data is defined in FIPS PUB 150, Telecommunications: Facsimile Coding Schemes and Coding Control Functions for Group 4 Facsimile Apparatus [4] (CCITT Recommendation T.6 [2]). It has no support for tiling, but has the virtue of simplicity.

Type II data is a MIL-STD-1840 header wrapped around an ODA-style document as specified in the NIST ODA Raster DAP. That ODA document may be tiled or may consist of a single compressed block of data as in Type I, but with all ODA parameters and data structuring included. An article published in Inform [18] describes the use of a tiling scheme for large images.

2.3 NIST ODA Raster DAP

The NIST ODA Raster DAP is an Office Document Architecture (ODA) DAP. ODA DAPs describe a restricted subset of the wide range of objects available under the ODA base standard, IS 8613, Information Processing - Text and office systems - Office Document Architecture (ODA) and Interchange Format. As such, DAPs relieve implementors of having to support features not of use to their group's application.

The NIST ODA Raster DAP published in MIL-R-28002A represents the position of the Open Systems Interconnection (OSI) Implementors Workshop (see **Involved Organizations**, section 5) as of the June 1990 workshop. The OSI Implementors Workshop continues to develop and refine the NIST ODA Raster DAP in the Working Agreements for Open Systems Interconnection Protocols document. It is anticipated that the NIST ODA Raster DAP will be moved into the Stable Implementation Agreements for Open Systems Interconnection Protocols document in December 1991. At the conclusion of this effort, it is anticipated that the NIST ODA Raster DAP will be proposed as a Federal Information Processing Standard (FIPS).

3 BENEFITS OF ODA

3.1 Compound Documents

With the emergence of compound documents, raster will become more useful and widespread.

Word processor vendors will soon be offering ODA export and import converters to allow documents received over data networks to be refined, modified, and re-used.

Since the NIST ODA Raster DAP is similar to other DAPs, the possibility exists that common platforms and raster editors will be used in the future for handling both large and small documents.

3.2 Relationship to Facsimile

The Consultative Committee on Telegraphy and Telephony (CCITT) has advanced a recommendation for a very simple ODA document application profile to support the needs of low-cost Group 4 facsimile hardware. This is known as CCITT Recommendation T.503, A document application profile for the interchange of group 4 facsimile documents [1].

Since the Group 4 facsimile world is adopting ODA, using ODA for the tiled representation of large document images offers certain advantages. It could be expected that the ODA orientation of the large new Group 4 facsimile market will make the choice of an ODA approach in MIL-R-28002A beneficial to the smaller market for large-document systems.[1]

Provisions exist in the international Profile Alignment Group for ODA (PAGODA) DAPs (see **Involved Organizations**, section 5) for the packaging of ODA documents as X.400 electronic mail messages, and also for the exchange of ODA documents using the File Transfer Access Method (FTAM) file transfer scheme for high speed networks. ODA is designed with interchange in mind.

3.3 Resistance to Using ODA

The resistance some people express after their first encounter with ODA [6] may come from the overwhelming avalanche of terms it has

---

[1] ODA through ISO 8613-7 allows both T.4 encoding (commonly known as "CCITT Group 3") and T.6 encoding (often called "CCITT Group 4"). In this discussion of machines (as yet not built) for Group 4 facsimile, it should be made clear that current Group 3 machines do not use ODA, although the exchange of "CCITT Group 3" data via ODA is possible in principle.

generated. Hearing ODA-fluent people discuss issues is like foreign language training by the immersion method.

Many everyday nouns and verbs are adopted by IS 8613, by ASN.1, or by the DAP proforma notation and made to function in new, alien roles. The recognition that this is common practice in any technical field (just ask a physicist, then a politician what "power" means) doesn't prepare one for the sheer volume of terms.

Luckily, it is only necessary to learn ODA at its most general level to complete an implementation of the MIL-R-28002A NIST ODA Raster DAP.

4 Overview of ODA

4.1 ODA's Relation to OSI

A new era of connectivity is beginning as the Open Systems Interconnection (OSI) standards are becoming very popular. ODA is clearly in the mainstream of OSI development and uses the mechanisms, formalisms, and abstract syntaxes that other OSI protocols use.

4.2 ODA's Base Standard: IS 8613

Each realm of OSI standards development has at its nucleus a single (or family of) base standard(s) that define(s) the building blocks available for creating more complex protocols or services. IS 8613, Information Processing - Text and office systems - Office Document Architecture (ODA) and Interchange Format [7-12] is the fundamental standard for ODA. Other standards also affect ODA work in some degree, but we will not discuss them in this document.

IS 8613 has several parts, each of which addresses some portion of ODA. The pertinent parts are discussed below.

> Part 1: Introduction and General Principles [7] gives a great many definitions of basic ideas. It describes the motivations and unifying design principles of ODA.
>
> Part 2: Document Structures [8] defines the basic elements of a document architecture and the conceptual models necessary to understand the layout and imaging processes. It also defines the different classes of allowed document architectures. The NIST ODA Raster DAP uses the formatted document architecture.
>
> Part 4: Document Profile [9] describes the purpose and attributes of a document profile.
>
> Part 5: Office Document Interchange Format (ODIF) [10] shows how to apply the ASN.1 encoding rules to ODA documents to prepare them for interchange as ODIF data streams (files).
>
> Part 7: Raster graphics content architectures [11] is the portion of IS 8613 that defines raster graphics content (data). All of the relevant attributes of raster data that need to be properly spelled out for successful interchange are identified. Allowed (permissible) values for those attributes and their defaults are all defined.
>
> Part 7 Tiling Addendum [12] contains the extensions to Part 7 necessary to implement tiling. Such attributes as tile size and tile type (how a tile is encoded) are specified.

4.3 ODA Encoding

ODA documents are data structures described or expressed in a notation which is independent of any particular machine in which the structures might be represented. In this way, problems with the particular manner in which, say, an integer might be represented on two different machines can be avoided. This notation is called an abstract syntax. In recognition of the fact that many such syntaxes are possible, the notation used in ODA and elsewhere in the Open Systems Interconnection (OSI) family of protocols is called Abstract Syntax Notation One (ASN.1).

ASN.1 is defined in two standards: IS 8824, <u>Information processing systems - Open Systems Interconnection - Specification of Abstract Syntax Notation One (ASN.1)</u> [13], and IS 8825, <u>Information processing systems - Open Systems Interconnection - Specification of Basic Encoding Rules for Abstract Syntax Notation One (ASN.1)</u> [14]. ASN.1 is further described in <u>The Open Book, A Practical Perspective on OSI</u> [17].

The first document describes ASN.1 syntax without defining the encoding rules that actually permit a protocol or interchange format to be put "on a wire" or in a file. The encoding of the syntax is a separate issue entirely.

The encoding represents the elements of the syntax as actual machine-readable symbols. These so-called Basic Encoding Rules are defined in IS 8825. They are called basic because other encoding rules are possible.

One other encoding called Office Document Language (ODL) is also defined in IS 8613-5. It is based on the Standard Generalized Markup Language (SGML). It is not permitted under the current MIL-R-28002A NIST ODA Raster DAP.

4.4 Document Application Profiles (DAPs)

Document Application Profiles (DAPs) are well-defined profiles, or subsets, of the ODA standard. Each DAP is created by a user group to meets its own needs. DAPs greatly limit the knowledge of ODA required for specific applications. The NIST ODA Raster DAP was initially created by the Tiling Task Group and then further developed through the efforts of the OSI Implementors Workshop. It has been simplified to meet the needs of the large-document and technical publications raster communities, particularly as they interact with the CALS program.

5 Involved Organizations

All of the organizations listed below have had some hand in either the format, the development, or the content of the hierarchy of standards embodied in the MIL-R-28002A Type II file format.

5.1 Government Initiatives

The Department of Defense Office for Computer-aided Acquisition and Logistic Support (CALS), the National Institute of Standards and Technology (NIST), and the industry-based Tiling Task Group (TTG) are the primary developers of the technical content of the Type II file format.

5.2 U.S. Initiatives

The OSI Implementors Workshop (OIW) is hosted by NIST and the Institute of Electrical and Electronic Engineers (IEEE) and meets quarterly. The ODA Special Interest Group (ODA SIG) meets under its auspices and undertakes North American development of ODA-related items, primarily DAPs. The NIST ODA Raster DAP is being developed, voted on, and approved by this group. The American National Standards Institute (ANSI) X3V1 committee is the North American contributor to the development of IS 8613 within the International Organization for Standardization (ISO).

5.3 International Initiatives

The international Profile Alignment Group for ODA (PAGODA) has undertaken to develop a common set of DAPs for world-wide use. These groups include the European Workshop for Open Systems (EWOS), the Asia-Oceania Workshop (AOW), the International Consultative Committee for Telegraphy and Telephony (CCITT), and NIST.

PAGODA is coordinating development of three related DAPs. These are known as FOD11, FOD26, and FOD36. Additionally, EWOS has initiated action to develop an Image (Raster) DAP.

6 File Structure

This section discusses the actual sequence of items inside an interchanged raster file. The iterative definition style permitted by ASN.1 and used by the DAP often causes some confusion in determining what information actually is transferred.

The ordering of data elements within an ODA document is specified in IS 8613 Part 5, section 5.3, where use of the class B data stream is mandated for this DAP.

The entire sequence of data items transferred is illustrated below in figure 1. Each of these items is discussed in greater detail in the next section, **ODA Constituents and Attributes.**

6.1 Raster Header Information

The several fields of this header are clearly spelled out in MIL-STD-1840.

6.2 ODA Header for Type II Data

Document Profile

This is the first item in the representation of an ODA document.

Presentation Styles

These items are optional, but if they do appear, they must occur next.

Document Layout Root

This must occur next and serves as the root for all basic pages that follow it.

Basic Page

There can be one or more basic pages. The term basic is applied to these pages because they are layout objects without any subordinate layout objects. Each page (in the tiled case) may have the following relevant entry among its sub-elements:

Tile Index

The optional tile index is present only in tiled files. The order of its elements matches the order of the tiles.

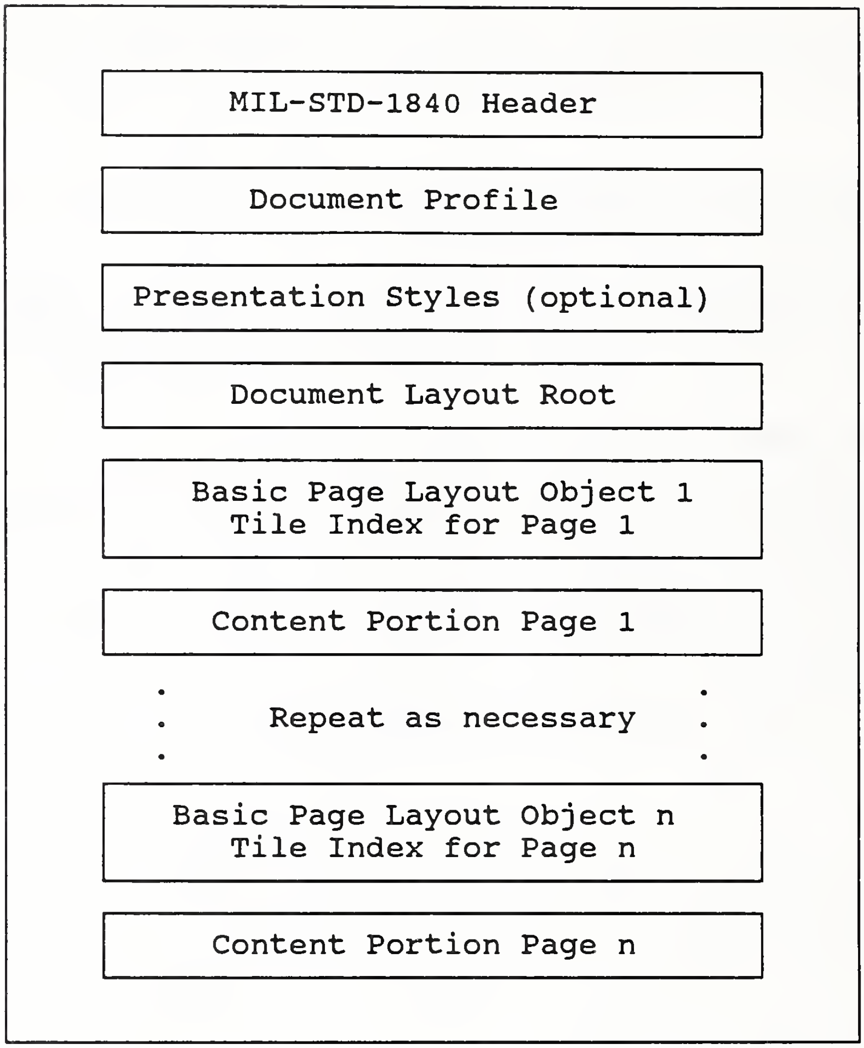


Figure 1. File Structure, Type II Tiled

Content Portion

The content portion is the actual raster data and its associated attributes for a single basic page. It immediately follows the layout description of that page. The data for tiles occur within that content portion in an order that is primarily along the pel (Picture Element) path direction and secondarily along the line progression direction.

The basic page and its associated content portion may occur alternately as many times as necessary to represent all the raster images in the document. Figure 1 shows the file structure of a MIL-R-28002A Type II file.

7 ODA CONSTITUENTS AND ATTRIBUTES

For the purpose of interchange, an ODA document is presented as a collection of constituents. Each constituent is a segment or portion of the interchange which contains a set of interrelated attributes. Each attribute describes a certain characteristic of that specific constituent or segment of the document. Constituents are often defined in an incremental way, with references being made back to earlier definitions. No constituent is used before it is defined.

The types of constituents used in the NIST ODA Raster DAP are: **document profile**, **presentation style**, **document layout description**, and **content portion description**. This order is as specified in IS 8613-5. The document layout description constituent consists of two objects: **document layout root** and **document layout page**. For multiple pages, the page and contents constituents repeat as shown in figure 1.

In the discussion below, the constituent, attribute, and attribute set names are shown in bold face when each term is being introduced or defined. The hyphens normally found in the names of items in the DAP have been removed for readability.

7.1 Document Profile

The **document profile** is a set of attributes which specifies the characteristics of the document as a whole. Some of these characteristics include the: DAP identifier, class of the specific document, basic structure of the document, and default values for attributes if they differ from the IS 8613 default values. Many of the attributes in the document profile are also used in other constituents, therefore the detailed discussion of the document profile is done after we discuss each of the other constituents (see **Detailed View of Document Profile**, paragraph 7.5).

7.2 Presentation Style

The **presentation style** is an optional constituent of the document which guides the format and appearance of the document content. If present, it must be referred to from the basic page. A style serves to group together sets of attributes which could alternately be applied directly and individually during the layout and imaging process.

The presentation style contains an attribute, **style identifier**, which identifies the presentation style uniquely within the context of the document. It is a sequence of two non-negative integers, the first of which is always '5' to signify a presentation style constituent. Since a document may contain more than one presentation style, a second integer is used to uniquely identify each presentation style within the interchange document. The value selected for this second integer may be any non-negative value as long as the integer sequence (integer pair) is unique for each presentation style. All other constituents using a specific presentation style must reference it using the integer sequence corresponding to the style identifier for that presentation style. In this way, a specific basic page layout object may refer to the presentation style needed to lay out the corresponding page.

For an example, a document may consist of six basic pages with two different presentation styles. The first style would have an identifier of '5 0' and the second a '5 1'. Both pages 1 and 5 could reference style '5 0' whereas all of the other pages 2, 3, 4, and 6 might reference style '5 1'.

Two optional attributes are the **user visible name** and **user readable comments**. These are textual information attributes.

The other attributes that may be used in the presentation style are grouped under the title presentation attributes.

Presentation Attributes

The **presentation attributes** is a set of attributes used to guide the presentation of the content information. The presentation attributes may be included in the presentation style or directly in the basic page (see **Presentation Styles**, paragraph 10.14).

Content architecture class is an attribute which specifies the class of content associated with a basic component of the document. It implicitly identifies a set of presentation attributes, control functions, and coding attributes which are applicable to that specific type of content. For example, raster graphics content requires a different set of attributes than does character content. For the NIST ODA Raster DAP, this attribute will always contain an object identifier of {2 8 2 7 2} designating the contents as raster 'formatted processable content architecture'.

Raster graphics attributes is a set of attributes that may be used and includes pel path, line progression, clipping, and pel spacing all of which are discussed below.

Pel path specifies the direction of progression of successive pels along a line and is expressed as a direction relative to the horizontal axis of the page coordinate system.

Line progression specifies the direction of progression of successive lines and is expressed as a direction relative to the pel path. Lines of pels are positioned such that the first pel to be positioned on each line falls on an imaginary line which passes through the initial point in the direction of line progression.

Clipping is used to determine the subregion of the entire pel array, as described by the content portion, which is to be considered by the content layout and imaging processes. It consists of two coordinate pairs. The first pair specifies the first pel that is part of the selected array. The second pair specifies the last pel that is part of the selected array.

Pel spacing specifies the distance between two adjacent pels along a line, in the direction of the pel path. Pel spacing is the distance measured using the unit Basic Measurement Unit (BMU). There are 1200 BMUs per inch. Pel spacing is expressed as a ratio. Thus a pel spacing of 6/1 is a ratio of a distance of 6 BMUs to one pel interval. Since 6 BMUs/pel * (1 inch / 1200 BMUs) = (1 inch / 200 pels), this corresponds to 200 pels per inch.

7.3 Document Layout Structure

The **document layout structure** consists of a series of layout objects. Each layout object has an associated set of attributes which specifies how the document content is to be laid out and presented to the viewer.

A specific layout structure of a document conforming to the NIST ODA Raster DAP is a simple two-level hierarchy consisting of a document layout root and a set of basic pages. See figure 2. The term "specific" is used to contrast with generic layout structure, an ODA feature omitted for simplicity from the NIST ODA Raster DAP. The document layout root and basic page have some attributes in common and some distinct attributes. The content information consisting of a raster graphics image, representing an engineering drawing, illustration, or other raster scanned image, can only be associated with a basic page. This content may contain either untiled or tiled raster graphics data.

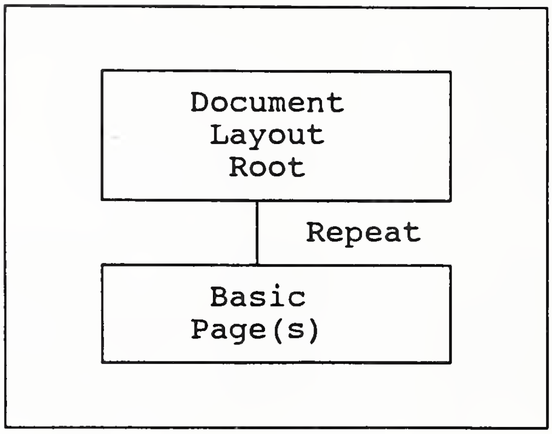


Figure 2 Specific Layout Structure

The **document layout root** is at the highest level of the hierarchy in a document layout structure. Its basic purpose is to identify the subordinate objects that exist at the second level of the hierarchy. For the NIST ODA Raster DAP, these subordinates can only be a sequence of one or more basic pages.

The **basic page** is a basic layout object that corresponds to the rectangular area used for presenting the raster content which represents an image.

Figure 3 illustrates the layout structure and associated contents for a specific document consisting of three basic pages. This illustration is used to describe several of the relationship attributes that are discussed in the remainder of this section.

Every layout object must include an **object type** attribute which specifies the type of object as being either the root or a basic page. The object type is then used to identify the set of attributes that may be specified for that specific object.

Because of the hierarchical nature of the layout structure, every layout object must be identified with an attribute, **object identifier**, which identifies the object uniquely within the context of the document and within the layout hierarchy. An object identifier consists of a sequence of integers. Each integer in the sequence corresponds to a hierarchical level and identifies one particular object instance at that level. For the three page example in figure 3, the document layout root, the first level of the hierarchy, is always identified with a '1'. The identifier on the first page contains a '1 0', the second page a '1 1', and the third page a '1 2'. The first integer in the sequence, '1', always indicates the object belongs to the specific document layout hierarchy. The second integer within the sequence uniquely identifies the page within that second level of the layout hierarchy, in other words, a '0', '1', or '2' for pages 1, 2, or 3 respectively.

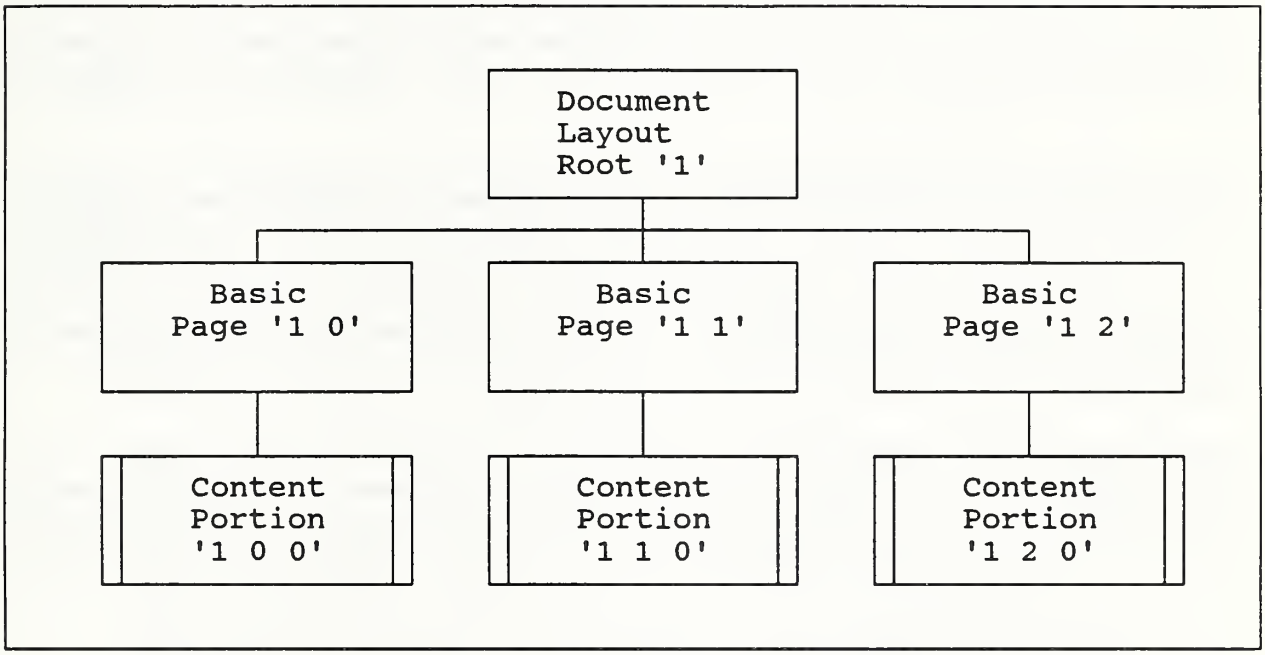


Figure 3 Illustration of Layout Structure

The document layout root additionally contains a relationship attribute, **subordinates**, which identifies the set of basic pages that are immediately subordinate to the document layout root. The value of this attribute is a sequence of one or more integers. Each integer corresponds to an immediately subordinate page. In our example, the value for subordinates would be '0 1 2' which corresponds to the second digit in the basic page object identifier. In other words, it identifies the pages 0, 1, and 2 as being subordinate to the root. In our interchange example, this attribute could be completely omitted because all the basic pages are implicitly assigned to the layout root. However, future implementations may require the use of this attribute so implementors should understand how the attribute may be used.

The basic page has a different relationship attribute, **content portions**, which functions similarly to the subordinates attribute. It is used to specify which content portions are associated with the basic page. Since there is only one content portion associated with each page, this value will always be a '0'. This is discussed below in **Content Portion Description**, paragraph 7.4.

An optional attribute is **dimensions** which specifies the rectangular size of the page in both the horizontal and vertical directions. It is specified in BMUs.

Another optional attribute is **position** which specifies the location on the page to start laying out the page content. It also is specified in BMUs.

The optional **application comments** is used when the content contains tiled raster graphics data. It contains a sequence of positive integers, one for each tile in the content portion. The sequence of integers is a set of indices representing the octet offsets to the beginning of the respective tiles, starting from the beginning of the **content information.** Content information is discussed in **Content Portion Description**, paragraph 7.4. The offsets will be sequenced in the same order as the tiles.

Other optional attributes associated with the basic page are: **presentation style**, **user visible name**, and **user readable comments**. The presentation style was discussed earlier. The user visible name and user readable comments are textual information attributes.

7.4 Content Portion Description

The **content portion description** is a constituent of the document which describes how the raster image is represented. The content portion description includes two parts: (1) the coding attributes, **content portion attributes**, needed to specify the properties of the content information; and (2) the actual **content information** (raster image). For the NIST ODA Raster DAP, each content portion will be laid out on a single basic page and will consist of only raster graphics content.

The **content portion attributes** is a set of attributes consisting of content identifier layout, type of coding, and raster graphics coding attributes.

> The **content identifier layout** is a relationship attribute which identifies a content portion description uniquely within the context of the document and is used to refer to that content portion description from the basic page layout object. It is a sequence of non-negative integers. For the NIST ODA Raster DAP, the sequence consists of three integers. The second

integer of the sequence identifies the basic page. The third integer uniquely identifies the content portion within a page. In our example in figure 3, the content portion belonging to the first page has a '1 0 0' and the content portion belonging to the second page has a '1 1 0'. Because only one content portion is allowed on a page in the NIST ODA Raster DAP, the third integer is always a zero. If the first page, '1 0', were allowed to contain a second content portion for an overlay, the corresponding identifier would be '1 0 1'. Therefore, both content portions, '1 0 0' and '1 0 1' would be laid out on the first page, '1 0'.

Type of coding is an attribute which specifies the coding used to represent the content information. For the NIST ODA Raster DAP, there are three types of coding: 'T.6 Encoding', 'Tiled Encoding', and 'Bitmap Encoding'.

'T.6 Encoding' indicates that the entire content information (image) is not tiled and is in compressed form in accordance with the CCITT T.6 algorithm.

'Bitmap Encoding' indicates that the entire content information (image) is not tiled and is in the uncompressed or bitmap form.

'Tiled Encoding' indicates that the content information is tiled and that each tile may then be represented in one of four possible ways: 'T.6 Encoding', 'Bitmap Encoding', 'null background', or 'null foreground' (see **Tile types** below).

Raster graphics (gr) coding attributes is a set of attributes which provide information required for encoding and decoding the content information as well as other information that is intrinsic to the content portion and required to layout and image the content. All of the attributes in this set deal with how to interpret the content data stream (content information), not how the image is to be presented on the display media. The attributes are defined as follows:

Number of pels per line specifies the number of pels in each line within the content information.

Number of lines specifies the number of lines of pels within the content information.

Tiling offset applies only to tiled content information. It specifies the location of the pel array within the tile space by defining the offset of the first pel of the pel array from the first pel position of the first tile. This is specified by a coordinate pair, consisting of two non-negative integers. Note that these integer values could be larger than the dimensions of a tile.

Tile types applies only to tiled content information. It is a sequence of integer values where each integer indicates the type of coding for the respective tiles in the content information. For the NIST ODA Raster DAP, the types of tiles allowed are: null background (0), null foreground (1), T6 encoded (2), and bitmap (5). If tile types is used (it is optional), there must be an integer value for each tile. If it is not used, all tiles must be T.6 encoded.

For the NIST ODA Raster DAP, the tiles are always square and are 512 by 512 pels in size. Consequently, the number of lines per tile and number of pels per tile line are never specified and, in fact, never appear in the DAP.

The **content information** is that part of the content portion description which is composed of the content elements, that is, the raster graphics content that is to be displayed. The content information, as specified by the type of coding attribute discussed above, may contain either T.6 encoded, tiled encoded, or bitmap raster graphics data.

7.5 Detailed View of Document Profile

Now that we have examined the overall structure and content of a document, let's return to a more detailed view of the **document profile**. Many of the attributes used in the profile can be used in other constituents which were described in the earlier paragraphs, but their use in the document profile is in a different context. Some of the attributes are mandatory and others are optional ("non-mandatory"). The attributes applicable to the document profile are defined in Table 1 at the end of this section. This table is a copy of Table 5 from the NIST ODA Raster DAP.

In the discussion that follows, each of the attributes from Table 1 is defined and described in the order in which it appears in the table. If it is desired to use a default value for any given attribute at the time of the document layout process, the default value must be specified in the document profile. Otherwise, the only default available for that attribute would be that default value specified in IS 8613.

Specific layout structure: An attribute used if and only if the document contains any specific layout descriptions. It specifies that specific layout objects are 'present' in the document. For the NIST ODA Raster DAP there will always be layout object descriptions.

Presentation styles: An attribute used if and only if the document contains any presentation styles, that is, the presentation style(s) is (are) 'present' in the document.

Document characteristics: A set of attributes which describes the characteristics of the document. Most of the attributes in the document profile are included within this set.

Document architecture class: An attribute which specifies the architecture class of the document. For the NIST ODA Raster DAP, this can only be the 'formatted' form which facilitates the reproduction of a document exactly as intended by the originator.

Document application profile: An attribute which specifies the Document Application Profile (DAP) that pertains to the document. Each DAP is assigned a unique identifier. This identifier is a number registered with the appropriate authorities to distinguish this DAP from any other. The proposed identifier (object identifier of {1 3 14 11 0 1 1}) assigned to the NIST ODA Raster DAP is the one to be used for interchanging raster graphics data under MIL-R-28002A.

Content architecture classes: An attribute which specifies the different classes of content allowed in the document. For the NIST ODA Raster DAP, only 'formatted processable raster content' is permitted. This is content (raster data) which carries some of the formatting intentions of the originator, but which still contains enough of the original information to be further manipulated by the receiving party.

Interchange format class: An attribute which specifies one of two types of Office Document Interchange Formats (ODIF) to be used, either 'A' or 'B'. Only class 'B' is permitted in the NIST ODA Raster DAP. The rules for using each class and specifying the order of the data stream are defined in IS 8613-5.

ODA version: An attribute identifying the standard and version to which the document conforms.

Document architecture defaults: A set of attributes that specifies the default attribute values for the document if the values are to be different from the default values specified in IS 8613. This set will be empty if all of the attributes for a specific document use the default values specified in IS 8613. The attributes in this set are listed below:

Content architecture class: An attribute which specifies the default value for the contents of the document. IS 8613 specifies the default value as 'formatted character content architecture' which is not allowed; it has no meaning in the context of raster data. Therefore, the NIST ODA Raster DAP has specified that this attribute is mandatory and the value must be an object identifier of {2 8 2 7 2} for raster 'formatted processable content architecture'.

Type of coding: The default encoding specified in IS 8613-7 for raster graphics data is 'T.6 Encoding'. If the default encoding for the document is to be tiled raster data, then this attribute will contain a value of 'Tiled Encoding'. The DAP does not allow the less useful default of 'Bitmap Encoding' to be applied to the entire document.

Page dimensions: An attribute which specifies the non-basic values of the "dimensions" attribute of layout objects of type 'basic page' used in the document. For a discussion of what "non-basic" means, see **non-basic document characteristics** below.

Medium types: An attribute which specifies the non-basic values of the "medium type" attribute used in the document.

Page position: An attribute which specifies the non-basic values of the "page position" attribute used in the document.

Raster graphics (gr) content defaults: A set of attributes which specifies the default attribute values for the specific raster graphics content within the document if the values are to be different from the values specified in IS 8613-7. None of the attributes in this set are mandatory. NIST ODA Raster DAP allows the use of four attributes:

(1) pel path, which normally has a default of 0,
(2) line progression, which normally has a default of 270,

(3) pel spacing, which normally has a default of 4 BMUs (300 pels/in.), and
(4) clipping, which normally has a default of (0,0) and (N-1,L-1), where N is the number of pels per line and L is the number of lines.

If a default of any value other than its normal default is desired, then the attribute and its default value must be included in the raster graphics content defaults.

This concludes our discussion of the attributes which make up the set of document architecture defaults. One more item remains in the set of attributes which occur in the document profile...

Non-basic document (doc) characteristics: A set of attributes used to specify the attribute values for the specific document if the values are non-basic. A non-basic value is a value for an attribute that is only allowed by the governing DAP (in this case the NIST ODA Raster DAP) to appear in the document interchange if its use is declared in the document profile. All vendors supporting the DAP would commonly be expected to support all the basic values, but vendors may not commonly be expected to support the non-basic values. Before processing a document, a receiving implementation should look at the non-basic document characteristics to ensure that it can continue processing the document. For example, a fall-back procedure might be invoked rather than simply quitting, e.g., displaying an image at half-size.

The specification of the values of the attributes in this set is mandatory only if non-basic values are to be used. For the NIST ODA Raster DAP, the allowable attributes are: page dimensions, medium types, pel path, line progression, and pel spacing. Note that the pel path, line progression, and pel spacing attributes are grouped within a set called Raster Graphics Presentation Defaults.

If and only if the image size is larger than the North American A-E and Legal sizes (spelled out as basic in the DAP) will the page dimensions and medium types attributes have to be declared in this section of the document profile. Any user's choice of an image size up to E is declared as basic in the DAP.

If a pel path of 180 or 270 degrees is to be used, then pel path will have to be included in this section of the document profile.

If a line progression of 90 degrees is to be used, then line progression will have to be included. And if a pel spacing of other than 6 BMU (corresponding to 200 pels/in.) or 4 BMU (corresponding to 300 pels/in.) is to be used, then pel spacing will also have to be included in this section of the document profile.

In summary then, the document profile has several attributes that may be used. Many of them are optional and defaultable so do not always need to be specified. Table 1, containing the complete list of these attributes, uses the following notation in the class column:

- o m mandatory attribute
- o nm non-mandatory attribute
- o M/NM are used for groups of attributes.

Table 1 Document Profile Attributes

Attribute	Class	Permissible Values
Specific-layout-structure	m	present
Presentation-styles	nm	present
Document-characteristics	M	
Document-architecture-class	m	formatted
Document-application-profile	m	{-- proposed id of 1 3 14 11 0 1 0 --}
Content-architecture-classes	m	{2 8 2 7 2}
Interchange-format-class	m	B
ODA-version	m	ISO 8613, 1989-07-04
Document-architecture-defaults	M	
Content-architecture-class	m	formatted processable
Type-of-coding	nm	T.6 Encoding (default) Tiled Encoding
Page-dimensions	nm	See DAP table 1, (Default is NA-A, 9240 x 13200 BMU)
Medium-types	nm	See DAP table 1, (Default is NA-A, 9240 x 13200 BMU)
Page-position	nm	any coordinate pair within page

Table 1 Document Profile Attributes (continued)

Attribute	Class	Permissible Values
Raster-gr-content-defaults	NM	
Pel-path	nm	0, 90, 180, 270 degrees (0 is normal default)
Line-progression	nm	90, 270 degrees (270 is normal default)
Clipping	nm	any coordinate pair within page
Pel-spacing	nm	6 BMU (200 pels/in.) 5 BMU (240 pels/in.) 4 BMU (300 pels/in.) 3 BMU (400 pels/in.) 2 BMU (600 pels/in.) 1 BMU (1200 pels/in.) (Normal default is 4 BMU)
Non-basic-doc-characteristics	NM	
Page-dimensions	nm	See DAP table 1, NA-F through NA-K, roll paper
Medium-types	nm	See DAP table 1, NA-F through NA-K, roll paper
Raster-gr-presentation-features	NM	
Pel-path	nm	180, 270 degrees
Line-progression	nm	90 degrees
Pel-spacing	nm	5 BMU (240 pels/in.) 3 BMU (400 pels/in.) 2 BMU (600 pels/in.) 1 BMU (1200 pels/in.)
Document-management-attributes	M	
Document Reference	m	Any string of characters

8 Detailed View of the DAP

8.1 Genealogy

The DAP was created by direct reference to CCITT T.503 [1], an extremely simple DAP which allows only a single piece of T.6 encoded raster content. Its simple structure formed an appropriate basis for the NIST ODA Raster DAP.

8.2 Simplifications

Many unnecessary items found in more fully-featured DAPs were intentionally left out. Primary among these items are elements of logical structure such as descriptions which allow for chapters, sections, and paragraphs. Other elements of the layout structure, such as blocks, frames, and page sets, were also omitted. The only pages allowed are simple, basic pages.

8.3 DAP Narrowed by MIL-R-28002A

Although some parameters in the DAP allow for great flexibility, several of these are further limited by MIL-R-28002A.

For example, the DAP follows the ODA convention that specifies a default pel spacing of 4 Basic Measurement Units (BMUs). This equates to 300 pels per inch. MIL-R-28002A requires 300 pels per inch for technical manuals and illustrations, but 200 pels per inch for large-format engineering drawings. This means that the defaulting mechanism inherent in the DAP cannot be used with engineering drawing scans.[2]

Bit ordering of uncompressed data is currently unclear among users of ODA, but is spelled out as Most Significant Bit (MSB) to Least Significant Bit (LSB) in MIL-R-28002A.

MIL-R-28002A requires systems to export images with sizes which are multiples of eight; the DAP has no similar restriction.

Using a checklist in MIL-R-28002A, other parameters are left to the determination of the contracting officer and may be narrowed by restrictive language in the contract document. These could include disallowing bitmapped tiles except in the case of reverse

---

[2] The DAP uses the notion of pel spacing rather than pels per unit length (the reciprocal). The pel spacing is thus a distance measured using the unit BMU (basic measurement unit). There are 1200 BMUs per inch. Pel spacing is expressed as a ratio, rather than simply as a number. A pel spacing of 6/1 is a ratio of a distance of 6 BMUs to one pel interval. Since 6 * (1/1200) = (1/200), this corresponds to 200 pels per inch.

compression, requiring rotation of the image to proper viewing orientation (rather than merely describing the proper viewing orientation), and requiring the zeroing of the unused portions of tiles. These issues are further considered in the **Technical Concepts** section. (See also MIL-R-28002A section 6.2.)

8.4 Proforma and Notation

The proforma and notation for ODA DAPs is defined in Annex F of IS 8613-1. It describes in detail the format for a DAP. It also specifies a meta-language to be used in writing a DAP, specifically the technical specifications in section 7.

The meta-language may be thought of as a higher level language similar to the high level programming languages such as COBOL, Pascal, etc. The ASN.1 Definitions may be thought of more like a lower level assembly programming language. However, in either case, the meta-language and ASN.1 Definitions define the structure of the Raster Interchange Format (RIF).

Note: The DAP in MIL-R-28002A was developed based upon a draft version of Annex F. Since publishing MIL-R-28002A, some changes have been made to the format of the proforma and notation in Annex F. These formatting differences will be corrected in the next version of MIL-R-28002 which will probably be published in late 1991.

The following terms are used in document application profiles. They are the reserved keywords of the DAP proforma and notation. Their definitions, as found in Annex F, are:

REQ	required.
PERM	permitted.
DIS	disallowed.
DEFINE	defines a macro.
SPECIFIC:	announces attributes specified for objects.
FACTOR:	announces a common set of constraints.
$	begins a macro invocation.
{ANY_VALUE}	any attribute or parameter value permitted by IS 8613.
#	indicates parameter or control function name.
[.]	indicates an optional syntactic item.

8.5 Elements of the DAP

The remainder of this section 8 of the tutorial discusses details of the different elements of the DAP and how they arise from the standards. The full text of the proforma and notation section of the NIST ODA Raster DAP is included (see **DAP Technical Specification**, paragraph 8.7). A DAP Technical Specification section is an unambiguous definition that can be read by automated systems such as compilers and test suites. These suites could check for consistency and implementability of the DAP. This is the objective of a project called Testing of ODA Compliance (TODAC), a joint effort of the Canadian Department of Communications and the United Kingdom National Computing Center. TODAC will also check ODA Office Document Interchange Format (ODIF) data streams for conformance to IS 8613.

8.6 Format of DAP Section 7

In section 7 of the DAP, there is a description for each type of constituent that is allowed in a document conforming to the DAP. Each description may include three primary elements of information: macro definitions, factor constraints, and constituent constraints.

Macro definitions provide a shorthand mechanism for use later in the notation.

Factor constraints describe the attributes and their associated values which apply to all constituents within that specific category, i.e., factor constraints for the layout structure apply to all the layout objects.

Constituent constraints describe the attributes and their associated values which apply specifically to each constituent in that category, i.e., for the layout structure, there is a constituent constraint for the Document Layout Root and one for Basic Page.

8.7 DAP Technical Specification

All of the paragraph numbers (7...) below in the smaller font are the same as defined in the DAP. They are retained in this section 8 for easy reference back to the DAP.

7 SPECIFICATION OF CONSTITUENT CONSTRAINTS

7.1 Document Profile Constraints

7.1.1 Macro Definitions

The page dimensions below are the dimensions of the entire scanned data set, prior to the application of clipping. The nominal page sizes are the sizes of the particular paper media on which the image is intended to be rendered.

```
-- Basic page dimensions. --
DEFINE(BasicPageDimension,"
  { #horizontal           { <=40800 },#vertical{ <=52800},
--  Any size equal to or smaller than the actual page size of ISO
A1 and ANSI E portrait.  --
  | #horizontal           { <=52800 },#vertical{ <=40800 } }
--  Any size equal to or smaller than the actual page size of ISO
A1 and ANSI E landscape.  --
")

-- Non-basic page dimensions. --
DEFINE(NonBasicPageDimensions,"
  { #horizontal           {40801..48000},   #vertical
  {52801..211200}
--  Any size larger than the range of basic values in ANSI E
portrait and equal to or smaller than the full size of ANSI K
portrait.  --
  | #horizontal           {52801..211200},  #vertical
  {40801..48000}}
--  Any size larger than the range of basic values in ANSI E
landscape and equal to or smaller than the full size of ANSI K
landscape.  --
")

DEFINE(NominalPageSizes,"

-- ISO Page Sizes --

  #horizontal {9920},     #vertical  {14030}
--  ISO A4 Portrait (210mm x 297mm)  --
  | #horizontal           {14030},   #vertical{9920}
--  ISO A4 Landscape (297mm x 210mm)  --
  | #horizontal           {14030},   #vertical{19843}
--  ISO A3 Portrait (297mm x 420mm)  --
  | #horizontal           {19843},   #vertical{14030}
 --  ISO A3 Landscape (420mm x 297mm)  --
  | #horizontal           {19843},   #vertical{28063}
--  ISO A2 Portrait (420mm x 594mm)  --
  | #horizontal           {28063},   #vertical{19843}
--  ISO A2 Landscape (594mm x 420mm)  --
  | #horizontal           {28063},   #vertical{39732}
--  ISO A1 Portrait (594mm x 841mm)  --
  | #horizontal           {39732},   #vertical{28063}
--  ISO A1 Landscape (841mm x 594mm)  --
  | #horizontal           {39732},   #vertical{56173}
--  ISO A0 Portrait (841mm x 1189mm)  --
  | #horizontal           {56173},   #vertical{39732}
--  ISO A0 Landscape (1189mm x 841mm)  --

-- ANSI Page Sizes --

  | #horizontal           {10200},   #vertical{13200}
--  ANSI A Portrait (8.5in x 11in)  --
  | #horizontal           {13200},   #vertical{10200}
--  ANSI A Landscape (11in x 8.5in)  --
```

```
  ¦ #horizontal           {10200},   #vertical{16800}
--  ANSI Legal Portrait (8.5in x 14in)  --
  ¦ #horizontal           {16800},   #vertical{10200}
--  ANSI Legal Landscape (14in x 8.5in)  --
  ¦ #horizontal           {13200},   #vertical{20400}
--  ANSI B Portrait (11in x 17in)  --
  ¦ #horizontal           {20400},   #vertical{13200}
--  ANSI B Landscape (17in x 11in)  --
  ¦ #horizontal           {20400},   #vertical{26400}
--  ANSI C Portrait (17in x 22in)  --
  ¦ #horizontal           {26400},   #vertical{20400}
--  ANSI C Landscape (22in x 17in)  --
  ¦ #horizontal           {26400},   #vertical{40800}
--  ANSI D Portrait (22in x 34in)  --
  ¦ #horizontal           {40800},   #vertical{26400}
--  ANSI D Landscape (34in x 22in)  --
  ¦ #horizontal           {40800},   #vertical{52800}
--  ANSI E Portrait (34in x 44in)  --
  ¦ #horizontal           {52800},   #vertical{40800}
--  ANSI E Landscape (44in x 34in)  --
  ¦ #horizontal           {33600},   #vertical{48000}
--  ANSI F Portrait (28in x 40in)  --
  ¦ #horizontal           {48000},   #vertical{33600}
--  ANSI F Landscape (40in x 28in)  --
  ¦ #horizontal           {13200},   #vertical{108000}
--  ANSI G Portrait (11in x 90in)  --
  ¦ #horizontal           {108000},  #vertical{13200}
--  ANSI G Landscape (90in x 11in)  --
  ¦ #horizontal           {33600},   #vertical{171600}
--  ANSI H Portrait (28in x 143in)  --
  ¦ #horizontal           {171600},  #vertical{33600}
--  ANSI H Landscape (143in x 28in)  --
  ¦ #horizontal           {40800},   #vertical{211200}
--  ANSI J Portrait (34in x 176in)  --
  ¦ #horizontal           {211200},  #vertical{40800}
 --  ANSI J Landscape (176in x 34in)  --
  ¦ #horizontal           {48000},   #vertical{171600}
--  ANSI K Portrait (40in x 143in)  --
  ¦ #horizontal           {171600},  #vertical{48000}
--  ANSI K Landscape (143in x 40in)  --

-- Foldouts --

    ¦ #horizontal         {13200},   #vertical{16800}
--  Foldout Portrait (11in x 14in)  --
    ¦ #horizontal         {16800},   #vertical{13200}
--  Foldout Landscape (14in x 11in)  --
  ¦ #horizontal           {13200},   #vertical{>= 16801}
--  Any portrait size larger than the typical foldout size (11in x
14in) including 11 inch roll paper --
  ¦ #horizontal           {>= 16801},#vertical{13200}
--  Any landscape size larger than the typical foldout size (14in
x 11in) including 11 inch roll paper --
")

DEFINE(FDA,"  formatted (0)")

DEFINE(DAC,"
Document-profile{#Document-characteristics
 {#Document-architecture-class}}  ")
```

```
DEFINE(FPR," {2 8 2 7 2}") -- Raster formatted processable --
```

7.1.2 Constituent Constraints

7.1.2.1 DocumentProfile

```
{

-- Presence of document constituents --

$FDA:    REQ Specific-layout-structure    {'present'},
         PERM     Presentation-styles     {'present'};

-- Document characteristics --

REQ  Document-application-profile      {-- Refers to clause 8
                                       of the MIL-R-28002A DAP for
                                       the permitted values for this
                                       attribute. --},

REQ  Doc-appl-profile-defaults         {

-- Document architecture defaults --
```

The Document architecture defaults section is used to define any defaults to be used in the data stream other than the standard ODA defaults.

```
REQ  #content-architecture-class   {$FPR},
PERM #dimensions                  {$BasicPageDimensions
                                  $NonBasicPageDimensions},
PERM #medium-type                 {
     REQ  #nominal-page-size      {$NominalPageSizes},
     REQ  #side-of-sheet              {ANY_VALUE} },
PERM #type-of-coding              {'T6 encoding'
                                  | 'tiled encoding'},
PERM #page-position               {ANY_VALUE},
PERM raster-gr-contents-defaults   {
     PERM  #pel-path              {ANY_VALUE},
     PERM  #line-progression      {ANY_VALUE},
     PERM  #pel-spacing           {ANY_RATIO = 6/1 4/1},
     DIS   #compression           {'uncompressed'},
     PERM  #clipping              {ANY_VALUE},
```

FDA, used below, indicates the formatted document architecture. This is used in this DAP to keep the document structure as simple as possible.

```
REQ  Document-architecture-class   {$FDA},
REQ  Content-architecture-classes  {$FPR},
```

FPR, used above, indicates formatted processable content. It is used in this DAP to allow access to the tiling mechanism that is only permitted in IS 8613 Part 7 Addendum under the formatted processable content architecture.

```
REQ  Interchange-format-class        {-- Refers to clause 8
```

```
                                                  of the MIL-R-28002A DAP
                                                  for the definition of the
                                                  permitted values for this
                                                  attribute. --},
REQ  ODA-version
     {#standard-or-recommendation {<character-string-constraint>
     ::= "ISO 8613"},
      #publication-date   {<character-string-constraint>
     ::= "1989-07-04"} },

-- Non-basic document characteristics --
```

The Non-basic document characteristics section is used to identify any non-basic attribute values contained in the data stream.

```
PERM #Page-dimensions {$NonBasicPageDimensions},
PERM #Medium-types             {
     REQ  #nominal-page-size   {$NominalPageSizes},
     REQ  #side-of-sheet       {ANY_VALUE},
PERM  #Ra-gr-presentation-features   {
     PERM #pel-path                  {'180-degrees'
                               '270-degrees'},
     PERM #line-progression    {'90-degrees'},
     PERM #pel-spacing         {ANY_RATIO <> 6/1 4/1},
     DIS  #compression         {'uncompressed'},
```

Basic values are: 6/1 (6 BMU / 1 pel space = 200 pels per inch) or 4/1 (300 pels per inch). All other values would be non-basic.

```
-- Document management attributes --

REQ  Document-reference        {ANY_VALUE}};
```

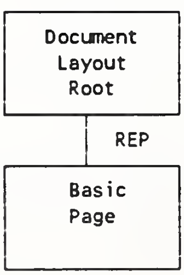
7.2 Logical Constituent Constraints

No logical constituents applicable in this subclause.

7.3 Layout Constituent Constraints

7.3.1 Diagrams of Relationships of Layout Constituents

The notation used for the structure diagrams is that specified in Annex A of ISO 8613-2.



7.3.2 Macro Definitions

None Applicable.

7.3.3 Factor Constraints

```
FACTOR:   ANY-LAYOUT                 {

SPECIFIC:
PERM  Object-type                    {VIRTUAL},
PERM  Object-identifier              {ANY_VALUE},
PERM Subordinates                    {VIRTUAL},
PERM User-visible-name               {ANY_VALUE},
PERM User-readable-comment           {ANY_VALUE},
}
```

The above attributes beginning with Object-type may be used in either the document-layout-root or the basic-page; this is what is meant by ANY-LAYOUT in this DAP.

```
FACTOR:   ANY-PAGE  :ANY-LAYOUT      {

SPECIFIC:
PERM Object-type                     {'BASIC-PAGE'},
PERM Dimensions                      {$BasicPageDimensions ¦
                                     $NonBasicPageDimensions},
PERM Page-position                   {ANY_VALUE},
}
```

Because there is only one type of page (basic-page), the above attributes can only be used with the basic page.

7.3.4 Constituent Constraints

7.3.4.1 DocumentLayoutRoot

```
DocumentLayoutRoot        : ANY-LAYOUT   {

SPECIFIC:
REQ  Object-type                     {'DOCUMENT_LAYOUT_ROOT'},
REQ  Subordinates                    {SUB_ID_OF(BasicPage)+},
}
```

Subordinate identifiers are used to uniquely identify each basic page under the DOCUMENT_LAYOUT_ROOT. The plus sign indicates an incrementing subordinate ID is associated with each succeeding basic page.

7.3.4.2 BasicPage

```
BasicPage           : ANY-PAGE       {

SPECIFIC:
REQ  Object-type                     {'BASIC_PAGE'},
PERM Medium-type                     {#nominal-page-size
                                     {NON_BASIC}, #side-of-sheet
                                     {ANY_VALUE}};
```

```
PERM Application-comments            {SEQ_INTEGERS},
                         -- See subclause 8.2 --
PERM Content-portions              {ANY_VALUE},
```

Raster graphics content occurs here because it is only associated with a basic page. This DAP has no other objects serving this purpose.

```
PERM Dimensions                    {#horizontal(
                                   #fixed(ANY_VALUE)),
                                   #vertical(#fixed(ANY_VALUE))
                                   ),
PERM Position                      {#fixed(ANY_VALUE)},
PERM Presentation-style            {STYLE_ID_OF(PStyle3},
PERM Presentation-attributes       {
     PERM  #raster-attributes          {
          PERM  Pel-path           {ANY_VALUE},
          PERM  Line-progression   {ANY_VALUE},
          PERM  Pel-spacing        {ANY_VALUE},
          PERM  Clipping           {ANY_VALUE} } }; }
```

The Presentation-attributes (above) can be attached directly to the basic page without the use of the presentation style mechanism. Alternatively, these attributes may be defined in a separate presentation style object, in which case, matching presentation style identifiers must be used in the basic page object (see **Presentation Styles**, paragraph 10.14).

7.4 Layout Style Constraints

No layout style constraints applicable in this subclause.

7.5 Presentation Style Constraints

7.5.1 Macro Definitions

```
DEFINE(R-Pres-Attr,"
PERM Pel-path                      {ANY_VALUE},
PERM Line-progression              {ANY_VALUE},
PERM Pel-spacing                   {ANY_VALUE},
PERM Clipping                      {ANY_VALUE},
 ")
```

7.5.2 Factor Constraints

```
FACTOR:   ANY-PRESENTATION-STYLE {
REQ  Presentation-style-identifier {ANY_VALUE},
PERM User-readable-comments        {ANY_VALUE},
PERM User-visible-name             {ANY_VALUE},
}
```

Because there is only one presentation style, these three attributes are only associated with PStyle3, defined in the next paragraph.

7.5.3 Constituent Constraints

7.5.3.1 PStyle3

```
PStyle3   :ANY-PRESENTATION-STYLE  {

REQ  Content-architecture-class        {$FPR},
PERM Presentation-attributes           {$R-Pres-Attr},
}
```

7.6 Content Portion Constraints

7.6.1 Raster Graphics Content Portion

```
DEFINE(T6,                              "ASN.1 {2 8 3 7 0}")
DEFINE(Bitmap,                          "ASN.1 {2 8 3 7 3}")
DEFINE(Tiled,                    "ASN.1 {2 8 3 7 5}")

PERM Content-identifier-layout {CONTENT_ID_OF(raster-content-
portion)},
PERM Type-of-coding              {$T6 ¦ $Bitmap ¦ $Tiled},
PERM Coding-attributes           {
PERM #Number-of-lines            {ANY_VALUE},
REQ  #Number-of-pels-per-line         {ANY_VALUE},
PERM #Number-of-pels-per-tile-line {512},
PERM #Number-of-lines-per-tile    {512},
 -- Note:     The number-of-pels-per-line and number-of-pels-per-tile-line need not be used in the DAP
             because they are fixed at 512 pels.
PERM #Tiling-offset              {ANY_VALUE},
PERM #Tile-types                 {'null background' ¦
                                 'null foreground' ¦
                                 'T.6 encoded' ¦
                                 'bitmap encoded'}
                                 },
PERM Content-information         {RASTER},
```

7.7 Additional Usage Constraints

No other usage constraints are currently defined.

9 Coding Concepts

9.1 ASN.1 Notation

ASN.1 provides a very formal and rigidly defined notation for describing protocols and standards. A good working knowledge of ASN.1 and the Basic Encoding Rules is essential to a successful implementation of a MIL-R-28002A Type II encoding or decoding program.

ASN.1 is a formal description language based on the concept of data types and values for those types. All objects to be interchanged are either primitive or constructed data types. Primitive types are simple elementary types such as an integer or octet string. Constructed types are those that have been built up from various simple types or other constructed types. A large set of predefined data types exists and application specific ones may be created.

ASN.1 provides powerful mechanisms for expressing the restriction of types to other types or to ranges of values.

Recursive definitions are permitted.

It would seem possible to implement MIL-R-28002A Type II in several ways: (1) compile section 7 of the DAP with a "DAP Compiler", which directly generates C code from the DAP (nothing like this yet exists), (2) compile the ASN.1 Definitions describing the DAP into C code using an ASN.1 compiler (these do exist), or (3) directly write C code or use any other programming language to implement the structures in the ASN.1 Definitions describing the DAP. It should be noted that there are certain semantical descriptions in the DAP that are not present in the ASN.1 Definitions; therefore, these semantical meanings are lost when using an ASN.1 compiler versus a DAP compiler. Similarly, when generating C code versus using an ASN.1 compiler, some of the rigidity and restrictions <u>may</u> be lost if the implementor is not careful.

9.2 Sample of ASN.1 Definitions

Below is an excerpt from the ASN.1 Definitions which represent the source statements for the implementation of the NIST ODA Raster DAP. The entire listing of this file appears in **ASN.1 Definitions**, Appendix A.

The definitions are in a form processable by the Free Value (Freeval) tool (see **Tools**, section 11). This file was used as input to the Free Value tool which was used to evaluate and verify the correct ASN.1 syntax. The tool was also used to insert values for parameters specific to a given document and to encode the transfer values (discussed later in this section).

This example of a Type II file illustrates the use of the full range of available parameters. Some parameters that could be defaulted to save small amounts of storage have been explicitly specified to help demonstrate how they are represented.

Comments may be used in ASN.1 and are identified with a double hyphen (--). This tutorial also uses additional comments which are interspersed within the ASN.1 Definitions and appear in a different font.

Excerpt....

```
--                    Interchange Data Element

Rif-Module
DEFINITIONS  ::=
BEGIN

Interchange-Data-Element        ::=  CHOICE {
   document-profile             [0]  IMPLICIT Document-Profile-Descriptor,
   layout-object                [2]  IMPLICIT Layout-Object-Descriptor,
   content-portion              [3]  IMPLICIT Text-Unit,
   presentation-style           [7]  IMPLICIT Presentation-Style-Descriptor
                                     }
```

All the objects to be interchanged are either primitive (simple, elementary) types like INTEGER, BOOLEAN, or OCTET STRING, etc., or are further defined as constructed (built up of other types).

The Rif-Module (raster interchange format) itself is the first such object definition which is a constructed type. It begins with a DEFINITIONS ::= and is contained within a BEGIN ... END block. An interchanged document can consist of several Interchange-Data-Elements. Which and how many of them are used will depend upon the contents of the specific document. The Rif-Module has the rules to create each interchange data element that the DAP might specify. For this reason, it is a CHOICE. A different recipe applies depending on which type of item is to be interchanged next. Each choice must be uniquely tagged, and is identified with a number in brackets. For example, the document-profile has a tag of zero. The document-profile is further defined by a reference to Document-Profile-Descriptor.

```
Document-Profile-Descriptor       ::=  SET {
   specific-layout-structure       [1]  IMPLICIT NumericString OPTIONAL,
   document-characteristics        [2]  IMPLICIT Document-Characteristics OPTIONAL,
   document-management-attributes  [3]  IMPLICIT Document-Management-Attributes OPTIONAL,
   presentation-styles             [6]  IMPLICIT NumericString OPTIONAL
                                        }
```

The document profile descriptor is a SET; that is, it consists of the items following in the braces, occurring in any order. Among those items, the ones listed as OPTIONAL are not mandatory.

IMPLICIT is a keyword which saves space when the data is reduced to bytes in the encoding process. It indicates that in building the tag for a given object, the type for the object is not needed.

The code that follows describes the usage formatted (0) for document-architecture-class. This indicates that the interchanged value is a zero, but that zero is simply the defined representation for the formatted type of document architecture class. The word 'formatted' is used in ODA ASN.1 Definitions as an enumerated data name. It has a value of zero and does not appear in the interchange data stream.

Note that the document-application-profile has an OBJECT IDENTIFIER assigned to it. This will be registered as a unique identifier for the NIST ODA Raster DAP when the DAP moves to the OSI Stable Implementation Agreements.

```
Document-Characteristics         ::=  SET {
   document-architecture-class   [1]  IMPLICIT INTEGER {
                                         formatted (0)}
                                          OPTIONAL,
   non-basic-doc-characteristics [2]  IMPLICIT Non-Basic-Doc-Characteristics
                                      OPTIONAL,
   document-application-profile  [4]  IMPLICIT OBJECT IDENTIFIER,
                                         -- {1 3 14 11 0 1 1},
                                         -- proposed object ID
   content-architecture-classes  [5]  IMPLICIT SET OF OBJECT IDENTIFIER OPTIONAL,
                                         --  { 2 8 2 7 2 },
   interchange-format-class      [6]  IMPLICIT INTEGER {if-b (1)},
   oda-version                   [8]  IMPLICIT SEQUENCE {
      standard                           Character-Data,
      publication-date                   Date-and-Time} OPTIONAL,
   doc-appl-profile-defaults    [10]  IMPLICIT Doc-Appl-Profile-Defaults OPTIONAL
                                      }
```

------------------- large portion skipped ------------------

```
-- RASTER GRAPHIC PRESENTATION ATTRIBUTES

Raster-Graphics-Attributes       ::=  SET {
   pel-path                      [0]  IMPLICIT One-Of-Four-Angles OPTIONAL,
   line-progression              [1]  IMPLICIT One-Of-Two-Angles OPTIONAL,
   clipping                      [4]  IMPLICIT Clipping OPTIONAL,
   pel-spacing                   [5]  Pel-Spacing OPTIONAL
                                      }
```

```
One-Of-Four-Angles            ::= INTEGER {
                                  d0   (0), --  0 degrees
                                  d90  (1), -- 90 degrees
                                  d180 (2), -- 180 degrees
                                  d270 (3)  -- 270 degrees
                                  }

One-Of-Two-Angles             ::= INTEGER {
                                  d90 (1), -- 0 degrees
                                  d270 (3) --270 degrees
                                  }

Measure-Pair                  ::= SEQUENCE {
    horizontal                 [0]  IMPLICIT INTEGER,
   vertical                   [0]  IMPLICIT INTEGER
                                  }
```

In the code above, we see a SEQUENCE for Measure-Pair. This is similar to a SET, except the ordering <u>must</u> be preserved.

9.3 The Basic Encoding Rules

The Basic Encoding Rules define one way to actually encode ASN.1 objects into binary values for interchange (transfer values) using a syntax called Office Document Interchange Format (ODIF). ODA permits other encoding rules to be used. In fact, a Standard Generalized Mark-up Language (SGML) encoding, using Office Document Language (ODL), is defined in ODA. However, the Basic Encoding Rules are the only rules currently specified in the NIST ODA Raster DAP (Appendix A to MIL-R-28002A).

A detailed understanding of the Basic Encoding Rules is not required to understand MIL-R-28002A Type II. In fact, users of a library of ASN.1 routines would probably never need to understand encodings at the bit or byte level. Only a programmer of elemental ASN.1 input and output routines would need such a detailed understanding. These individuals should refer directly to ASN.1 (IS 8824) and Basic Encoding Rules (IS 8825) standards to assure a proper implementation.

This section provides a brief introduction to the Basic Encoding Rules. The key idea is that these codes are best left to programs to read and write. One would not wish to read a business letter by viewing hexadecimal ASCII codes; one would use a word processing program.

The Basic Encoding Rules are similar to many file formats in that for each object they encode, they specify a type, a length, and then a value. Each type is specified by a tag.

Each tag belongs to one of four classes of tags, defined by a two bit pattern. A tag also has a five bit tag number which was chosen in each case to be unambiguous in the context of other tags. A one bit flag, which indicates whether the value to which the tag refers, is constructed or primitive is also present in the tag. Constructed values or objects are built up from other objects.

Figure 4 indicates how the tag identifiers are built up from the class, tag number, and constructed flag of a given ASN.1 object. Tag identifiers also have a long form for handling tag numbers greater than 30. We show only the short form.

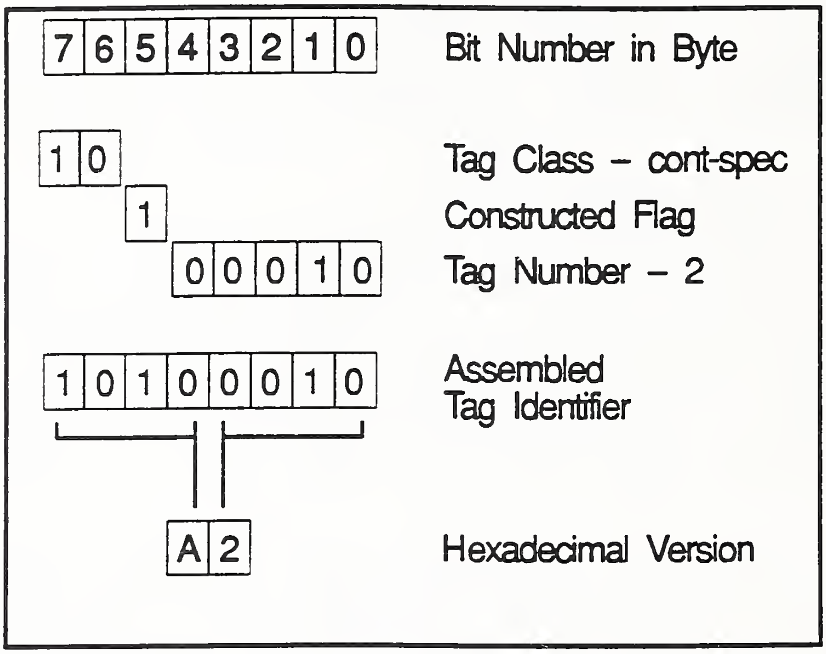


Figure 4. Constructing Tag Identifiers.

There are four classes of tags. Shown below are their names, their two-bit codes used in constructing tag identifiers, and their use:

Universal	00	Types that are defined in IS 8824, e.g., INTEGER, OCTET STRING. [13]
Application	01	Types that are defined for the specific application, e.g., ODA has defined APPLICATION 0 to be a string containing only digits and spaces.
Context-specific	10	Types which are defined only for a specific context such as SET or

SEQUENCE which were illustrated earlier.

Private	11	Not used in MIL-R-28002A.

The length associated with an object includes the length of all objects contained within it. Figure 5 shows the two length encoding schemes: definite and indefinite length. The definite length method can have either a short or a long form. The short definite form is only valid for contents with a length of 0 to 127 whereas the long definite form is valid for any definite length, including small values that could use the short definite form. For primitive objects and simpler constructed objects, it is relatively easy to anticipate their length. In this situation, the definite length encoding is used.

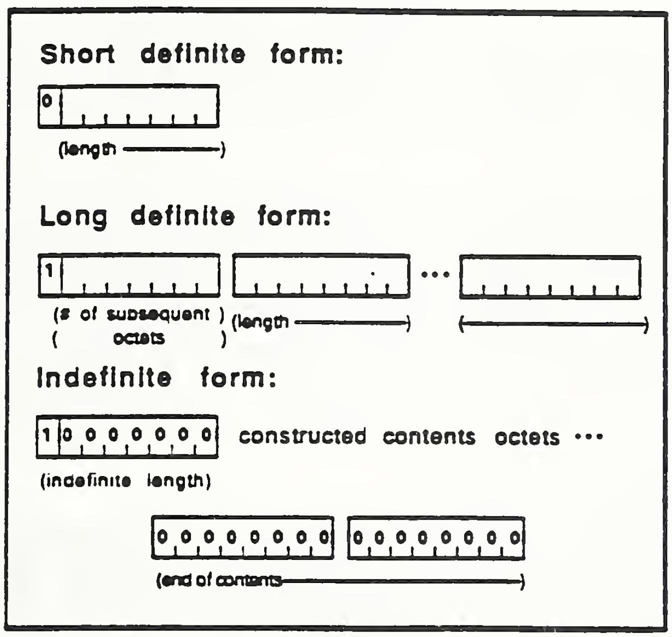


Figure 5. Definite and Indefinite Length Encoding.
This figure is extracted from Gaudette [5].

For complicated tagged objects, it might not be possible to determine their lengths until the lengths of their sub-elements are known. In this case, indefinite length encoding becomes useful. This method begins the object without specifying its length. A sequence of sub-elements then appears. The end of the object is marked by appending an end-of-contents flag, two bytes of zeros.

Indefinite length encoding may be easier for a *writing program* when it encounters complicated objects, but it makes a *reading program's* job more difficult: it is not possible to simply skip over the large object even if it is not of interest--it must be parsed in detail in order to find the end-of-contents flag. This parsing examines only the type and length of each sub-element. Each sub-element which is not an end-of-contents flag can then be skipped over by use of its length information.

9.4 Transfer Values

Transfer values are hexadecimal listings that specify the actual binary octets (bytes) placed in an interchanged file. They are the result of applying the Basic Encoding Rules to the ASN.1 Definitions. A standard indenting scheme makes it easier to understand the nesting of objects.

Although the DAP notation and ASN.1 Definitions describe the entire range of all possible interchanged files, the transfer values is very specific--it describes a single instance of an interchanged file.

Test Chart Data, Appendix B, contains the entire listing of the data values describing a particular test chart document. The Free Value tool can insert these specific data values into the ASN.1 Definitions found in Appendix A. The resulting transfer values are shown in **Test Chart Transfer Values**, Appendix C. The reminder of this section contains an excerpt from the Appendix C transfer value listing along with some explanations describing how the transfer values were derived. The listing was produced by the Free Value tool (see **Tools**, section 11).

The only items which actually appear in the interchanged data are the octets shown as hexadecimal values; words, decimal points, or items in angle or square brackets are placed in the listing by the Free Value tool to aid readability and do not occur in the interchanged data.

Items in angle brackets are decimal lengths. Items in square brackets are decimal tags. Items occurring in pairs are hexadecimal digits. Each pair of hexadecimal digits represents one octet. In the discussion below, binary values are shown in parentheses. While going through this encoding, it is helpful to refer to the ASN.1 Definitions describing the Interchange-Data-Element in the Rif-module (see **ASN.1 Definitions**, Appendix A).

```
<201>
a0 81 c6  [0] constr <198>
```

Each Interchange-Data-Element in the transfer values listing begins with a decimal number in angle brackets showing the length in octets of the entire Interchange-Data-Element. Encoding the first CHOICE, document-profile, of the Interchange-Data-Element results in the first transfer entry 'a0 81 c6'. The tag identifier 'a0', refer to figure 4, stipulates a context-specific (10), constructed (1) transfer value with a tag of zero (00000):

```
(10      )
(  1     )
(   00000)
----------
(10100000)  =  a0 hexadecimal.
```

From the ASN.1 Definitions, we know that the item having the tag [0] in the present context is the document-profile. From this, we see that the document-profile is of type Document-Profile-Descriptor.

The '81' uses the long definite form of length and specifies the number of octets in the length value of the structure that will follow. That is, the first bit of the octet (1) designates a long definite form and therefore the following bits (0000001) is a length indicating that one octet follows which in turn contains the length of 'c6' for the document-profile. The actual length of the value for the document-profile is 'c6' or 198 octets.

```
. 81 01  [1] <1>
  31
```

Encoding the first element in the SET of the Document-Profile-Descriptor, specific-layout-structure, results in the second and third entry '81 01 31'. The '81' stipulates a context-specific (10), primitive (0), transfer value having tag (00001). From the ASN.1 Definitions, we know the item having the tag [1] in the present context is the specific-layout-structure. Also from the ASN.1 Definitions, we know that this object's value is a Numeric String represented by ASCII characters. The length of the transfer value, '01', is one octet shown in the short definite form and the value is '31'. In this example, there is only one such character in the string, and it represents the number one.

```
. 86 01  [6] <1>
  31
```

Encoding the fourth element in the SET of the Document-Profile-Descriptor, presentation-styles, results in the fourth and fifth entry '86 01 31'. The '86' stipulates a context-specific (10), primitive (0), transfer value for the presentation-styles (00110), tag [6]. Again, the length of the transfer value, '01', is one octet in the short definite form and the value is '31' which is a single digit Numeric String.

```
.  a2 81 a4  [2] constr <164>
```

Encoding the second element in the SET of the Document-Profile-Descriptor, document-characteristics, results in the sixth entry 'a2 81 a4'. The 'a2' stipulates a context-specific (10), constructed (1), transfer value for document-characteristics (00010), tag [2]. The '81' again is a long definite form with the 'a4', or 164, being the length in octets of the document-characteristics object.

```
. .  81 01  [1] <1>
        00
```

Encoding the first element in the SET of the Document-Characteristics, document-architecture-class, results in the seventh and eighth entry '81 01 00'. The '81' stipulates a context-specific (10), primitive (0), transfer value for document-architecture-class (00001), tag [1]. The length of '01' indicates that the following value is contained within the one octet. The transfer value, '00', is an integer value of zero to indicate a formatted document-architecture-class.

NOTE: This tag of '81' is the same as occurred earlier on the second entry, but because it is located in a different area of the data stream, it has a different meaning. This illustrates why the term "context-specific" is used to describe this type of tag.

```
. .  a2 2f  [2] constr <47>
```

Encoding the second element in the SET of the Document-Characteristics, non-basic-doc-characteristics, results in the ninth entry 'a2 2f'. The 'a2' stipulates a context-specific (10), constructed (1), transfer value for non-basic-doc-characteristics (00010), tag [2]. The length of '2f' is a short definite form indicating the non-basic-doc-characteristics object is 47 octets long.

```
. . .  a2 0a  [2] constr <10>
```

The item <10> in the line above is a comment which indicates that this object is ten bytes long. We already knew this, however, because the hexadecimal '0a' earlier on the line is the length specifier. Counting the bytes in the five lines below which go to a deeper level of indenture (more than four dots) shows there are indeed ten bytes making up this object, not counting the one tag byte and one length byte of 'a2 0a'.

```
. . . . 30 08  [UNIV 16] constr <8>
. . . . . 80 02  [0] <2>
          27 d8
. . . . . 80 02  [0] <2>
          33 90

. . . a8 0f  [8] constr <15>
. . . . 30 0d  [UNIV 16] constr <13>
. . . . . 30 08  [UNIV 16] constr <8>
. . . . . . 80 02  [0] <2>
            27 d8
. . . . . . 80 02  [0] <2>
            33 90
. . . . . 02 01  [UNIV 2] <1>
          00

. . . a4 10  [4] constr <16>
. . . . 89 01  [9] <1>
        00
. . . . 8a 01  [10] <1>
        03
. . . . ac 08  [12] constr <8>
. . . . . a0 06  [0] constr <6>
. . . . . . 02 01  [UNIV 2] <1>
            04
. . . . . . 02 01  [UNIV 2] <1>
            01
```

Referring to the object represented in the eleven lines above and beginning with a4 10 [4] constr <16>, we see that it is a constructed object made up of smaller objects. The word "constr" inserted by the Free Value tool is actually redundant. We could have come to the same conclusion by several other means: (1) the indenting structure below that line shows other objects; or (2) the bit structure of an a4 by the Basic Encoding Rules indicates a constructed type (bit 6 of 8 is a 1).

The [4] on that same line is the tag number of that object in this current context, non-basic-doc-characteristics. This context sensitivity means that another object of a completely different type may also have the same tag, but one can tell them apart because both will never appear in the same context. The 4 was extracted from the tag a4.

```
. . 84 06  [4] <6>
    2b 0e 0b 00 01 01
. . a5 06  [5] constr <6>
. . . 06 04  [UNIV 6] <4>
      58 02 07 02
. . 86 01  [6] <1>
    01
. . a8 16  [8] constr <22>
. . . 43 08  [APPL 3] <8>
      49 53 4f 20 38 36 31 33
. . . 44 0a  [APPL 4] <10>
      31 39 38 39 2d 30 37 2d 30 34
. . aa 43  [10] constr <67>
. . . a0 2f  [0] constr <47>
```

```
. . . . . 80 04  [0] <4>
          58 02 07 02
. . . . . a2 08  [2] constr <8>
. . . . . . 80 02  [0] <2>
            27 d8
. . . . . . 80 02  [0] <2>
            33 90
. . . . . a6 0d  [6] constr <13>
. . . . . . 30 08  [UNIV 16] constr <8>
. . . . . . . 80 02  [0] <2>
              27 d8
. . . . . . . 80 02  [0] <2>
              33 90
. . . . . . 02 01  [UNIV 2] <1>
            00
```

Above we see several tags identified by the Free Value tool as UNIV 2, UNIV 16, UNIV 6, APPL 3, APPL 4, etc. These universal tags are identified in IS 8824 Table 1 as below:

UNIV 2	Integer type
UNIV 6	Object identifier type
UNIV 16	Sequence and Sequence-of types

The application tags are defined within the ODA realm of "application." They are shown in IS 8613 Part 5 Annex B to be:

APPL 3	Character-Data
APPL 4	Date-and-Time

```
. . . . . a9 06  [9] constr <6>
. . . . . . 80 01  [0] <1>
            00
. . . . . . 80 01  [0] <1>
            00
. . . . . aa 06  [10] constr <6>
. . . . . . 86 04 ` [6] <4>
            58 03 07 05
. . . . a2 10  [2] constr <16>
. . . . . 80 01  [0] <1>
          00
. . . . . 81 01  [1] <1>
          03
. . . . . a5 08  [5] constr <8>
. . . . . . a0 06  [0] constr <6>
. . . . . . . 02 01  [UNIV 2] <1>
              04
. . . . . . . 02 01  [UNIV 2] <1>
              01
. a3 17  [3] constr <23>
. . a7 15  [7] constr <21>
. . . a5 13  [5] constr <19>
. . . . 43 11  [APPL 3] <17>
          74 69 6c 69 6e 67 20 74 65 73
          74 20 69 6d 61 67 65
```

... Creating transfer values continues until all ASN.1 Definitions have been satisfied ...

10 Technical Concepts

This section discusses questions likely to arise in the minds of implementors in the course of reading MIL-R-28002A or the DAP. Much of the explanation given in this section would have been inappropriate to include in a military specification, which is intended to be brief.

10.1 Encoders and Decoders

It is worth noting that encoders (writers) and decoders (readers) of Type II files have differing needs for generality.

Programs which create Type II files may be relatively simple because they may be hard-coded to produce a specific file that meets the specifications of the contract and that still remains compliant with the document application profile (DAP). This allows a simpler conversion of data out of a given system format for export to other organizations.

For example, encoding programs may use definite or indefinite length encoding, may or may not include the optional tile index, may or may not zero out unused portions of partial tiles, may or may not create documents with sizes divisible by eight, etc. Writers may freely rely on default values for as many parameters as they are allowed according to the DAP.

Programs decoding Type II files must be more general in that they must be prepared to receive data from a wide range of writers, each of which is producing files in the manner simplest for them.

10.2 Converters versus Native Systems

Systems that store data internally in a format close to that of an ODA document are called native systems. There is some advantage to having a native system, although differing implementation requirements may make it impractical in many cases.

Non-native systems must implement file converters for translation of interchanged documents. This can add some overhead at import and export time.

10.3 Bit Order

The proper ordering of bits within bytes (octets) is a subject of industry-wide dispute. The traditional method in facsimile equipment for compressed data is to pack code bits into bytes in "up" fashion, that is, least significant bit (LSB) to most significant bit (MSB). The most widespread method used in sending bitmapped (uncompressed) data to computer display adapters is with a "down" ordering (MSB to LSB). This MSB to LSB bit ordering has also become a common representation for **compressed** data in many PC and workstation implementations.

In the absence of any clear and decisive word from the ISO/CCITT/ODA community, the Department of Defense directed in MIL-R-28002A that the MSB to LSB bit ordering be used for both uncompressed and compressed data.

It is conceivable that ISO/CCITT will rule that for ODA implementations these two differing techniques be used: the "up" direction for instances of compressed data and the "down" direction for instances of bitmapped data. This means that both orderings could occur among tiles of the same image.

In light of all this uncertainty, it is recommended that readers of Type II files be prepared to handle both bit orderings of the compressed data stream. MIL-R-28002A states that according to the interchange needs of a given contract, this may be specified as a requirement.

In the design process, it would be prudent to plan for writing and reading both compressed bit orderings, especially if such support comes more cheaply during the early development phases.

If the ODA community adopts the same approach, MIL-STD-1840 will have to be modified to support a bit-ordering flag, so both kinds of files can be identified.[3]

10.4 Padding/Byte Boundaries

Some systems may derive efficiencies from handling documents which have sizes which are multiples of eight. MIL-R-28002A requires an encoding program to export documents having such sizes.

Decoding programs may be required by contract to import documents from other systems which allow for arbitrary dimensions. They may do this either natively, or by padding out lines with zeros to

---

[3] It is possible to automatically sense the uncompressed bit ordering by considering both possibilities among many pairs of adjacent bytes--the proper bit order is the one which, on average, maximizes the white or black run lengths. In T.6 compressed data, it is also possible to sense the bit order--simply examine the last few bytes of the compressed block for the end-of-facsimile-block (EOFB) code. They will be 00h 10h 01h (or a bit-shifted equivalent) for the MSB to LSB case and 00h 08h 80h (or a bit-shifted equivalent) for the LSB to MSB case.

dimensions which are multiples of eight, or by truncation (since it is unlikely that this will lose significant data).

A related issue is whether compressed data has byte boundary constraints. The T.6 standard assumes that a T.6 compressed data block will have zeros (called pad bits) placed after the valid bits in the last, partial byte. The next data item begins on a byte boundary. Byte boundaries are a major issue only for T.4 compression, which is not permitted under MIL-R-28002A.

10.5 Partial tiles

In Type II tiled files, a document's size along either dimension will generally not be a multiple of 512 pels. This means that some unused data can exist in tiles around any or all of the document's four edges. In IS 8613 Part 7, this unused data is not considered to be information. Please refer to figure 6.

Decoding programs should therefore behave as if garbage data will exist in those pels and guard against its presentation.

Unless specified in the contract that the un-imaged pels be set to background, encoding programs have the option of leaving garbage in those pels or zeroing them out prior to compression. It is understood that compression will improve if zeros are in the unused portion of the tile.

It is further understood that some systems may get a needed price or performance benefit from not zeroing that data. For example, at a quality assurance (QA) workstation, an operator may perform dynamic clipping of scans of poorly registered aperture cards. Leaving garbage in the partial tiles and simply changing the clipping parameters in the file would avoid having to recompress the peripheral tiles.

Referring again to figure 6, we notice it shows only one band of partial tiles around the periphery of the tile grid. This is not the only possible case; it is possible to have one or several unused tile(s) between any partially used tile and the edge of the tile grid. For the upper left corner of the pel array, this is equivalent to saying that the tiling offset measure pair coordinates are not necessarily less than or equal to 512. This is not a particularly useful feature, but it should be planned for in implementations.

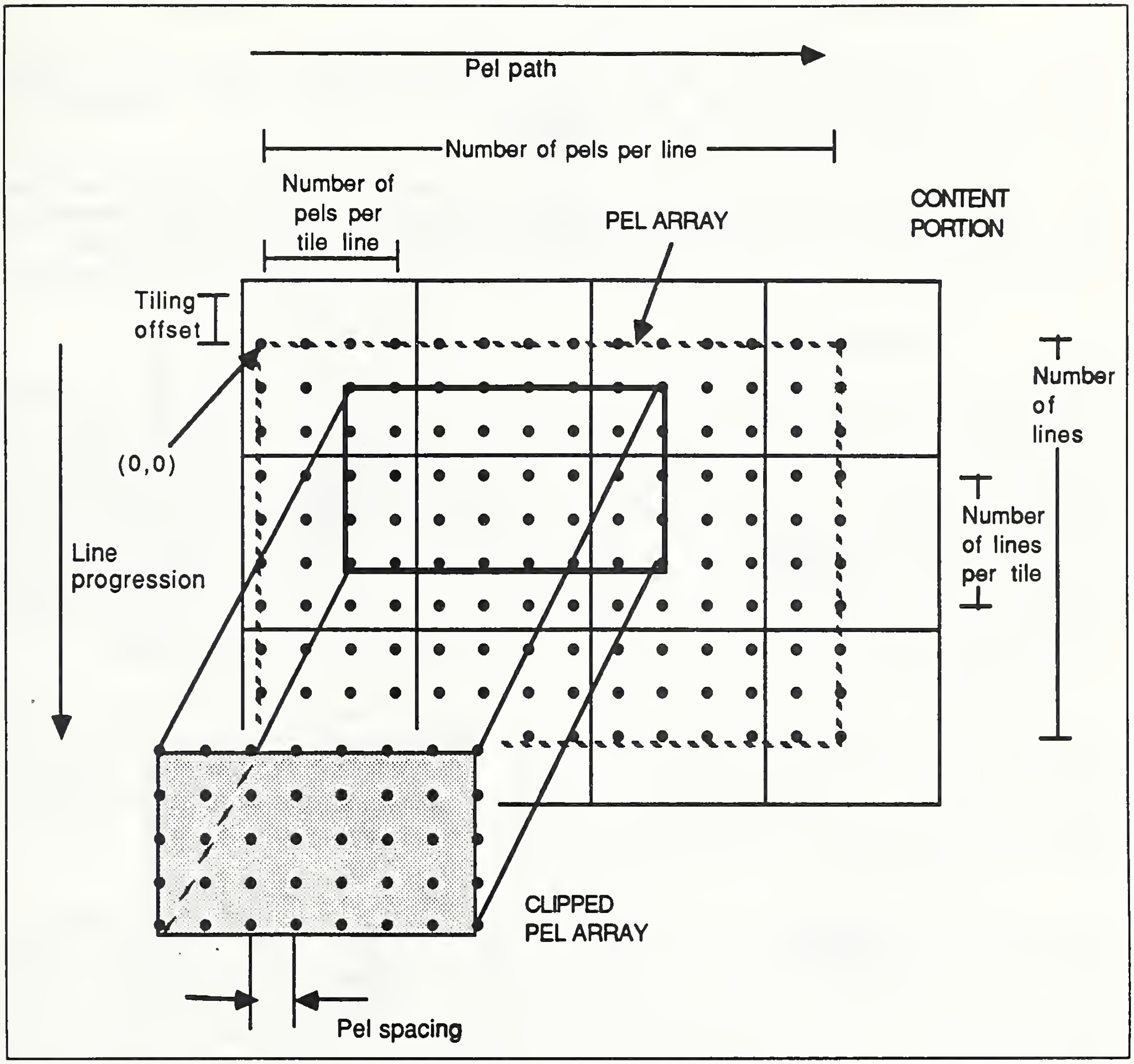


Figure 6. Tile array and partial tiles.

What is particularly useful is the clipping function illustrated in figure 6. This feature allows an intelligent scanning subsystem to identify the borders of the "good" region of the scan and merely paste the appropriate clipping coordinate pairs into the file. It does not need to recompress the tiles to remove the trimmed areas.

10.6 Tile Ordering

During interchange, the tiles must appear in the file in an order which is primarily along the pel path direction and secondarily along the line progression direction.

Many systems have to internally store tiles in random order because the tiles leave parallelized hardware in unpredictable order or because a series of tile-local editing sessions have occurred. At interchange time, however, these tiles must be properly ordered.

10.7 Orientation

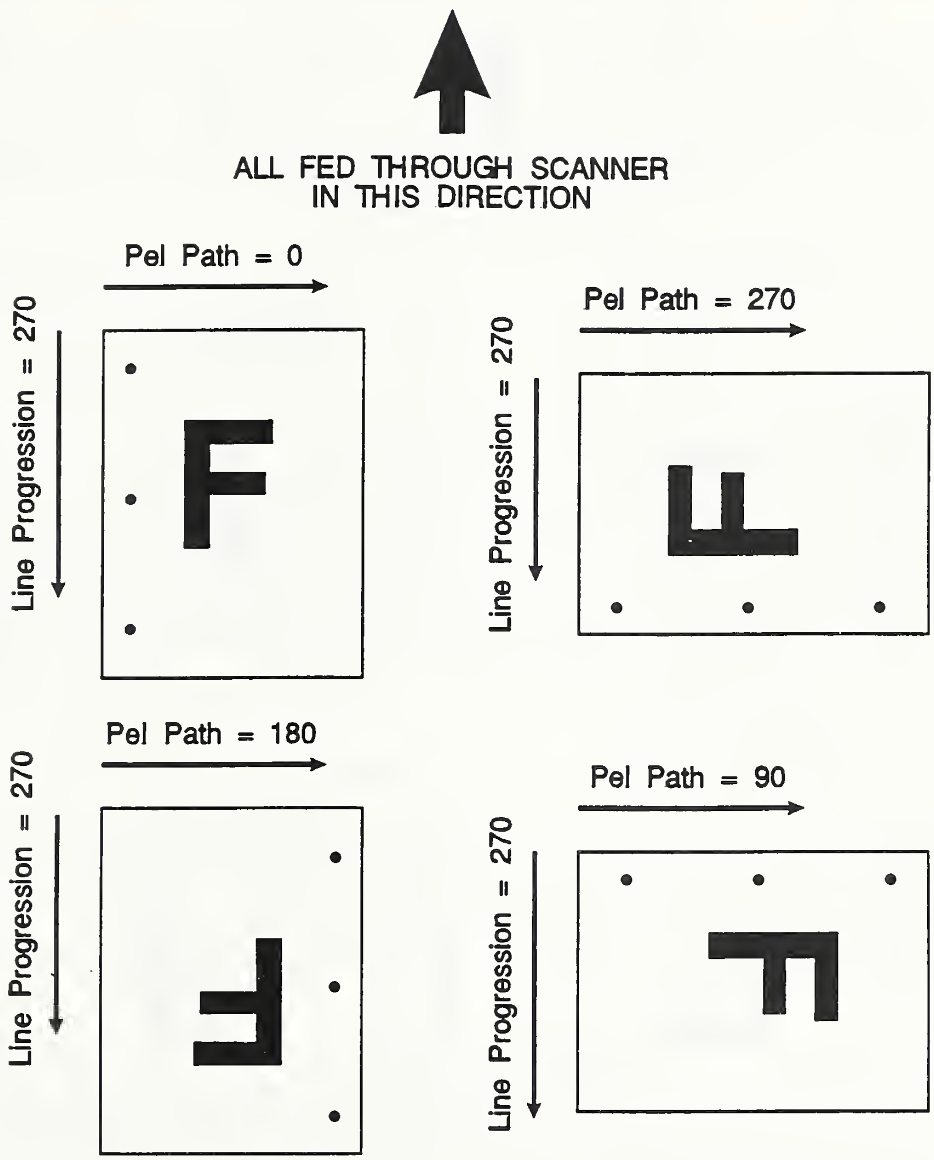
For Type II documents, the manner in which the ODA raster architecture deals with orientation requires the use of two attributes. The pel path and line progression directions specified for the document at interchange time guide the reader during the imaging process. To get proper viewing, a reader will take pels from a compressed or uncompressed data stream (file) and place them on the screen or paper in the directions indicated. The decoding program will lay down the first line of pels along the pel path direction and the second line along a path parallel to the first, but displaced from it along the line progression direction.

The decoding system knows its own requirements. If the target device is a display, the pels may be placed in memory in one organization. If the target device is a narrow printer, the pels may be placed in memory by the decoding program in a different way. The point is that the orientation parameters found in the file are purely descriptive, not prescriptive.

The pel path direction may have any of four values and the line progression direction can be at either of the two possible right angles to it. Therefore, this model can describe images which are not only rotated, but also mirrored either vertically and/or horizontally. This allows the orientation parameters to describe how to image a file which might have resulted from scanning the back side of an aperture card or paper sepia. This procedure might have been done in order to improve image quality.

Refer to figures 7 and 8 for an illustration of the possible orientations.

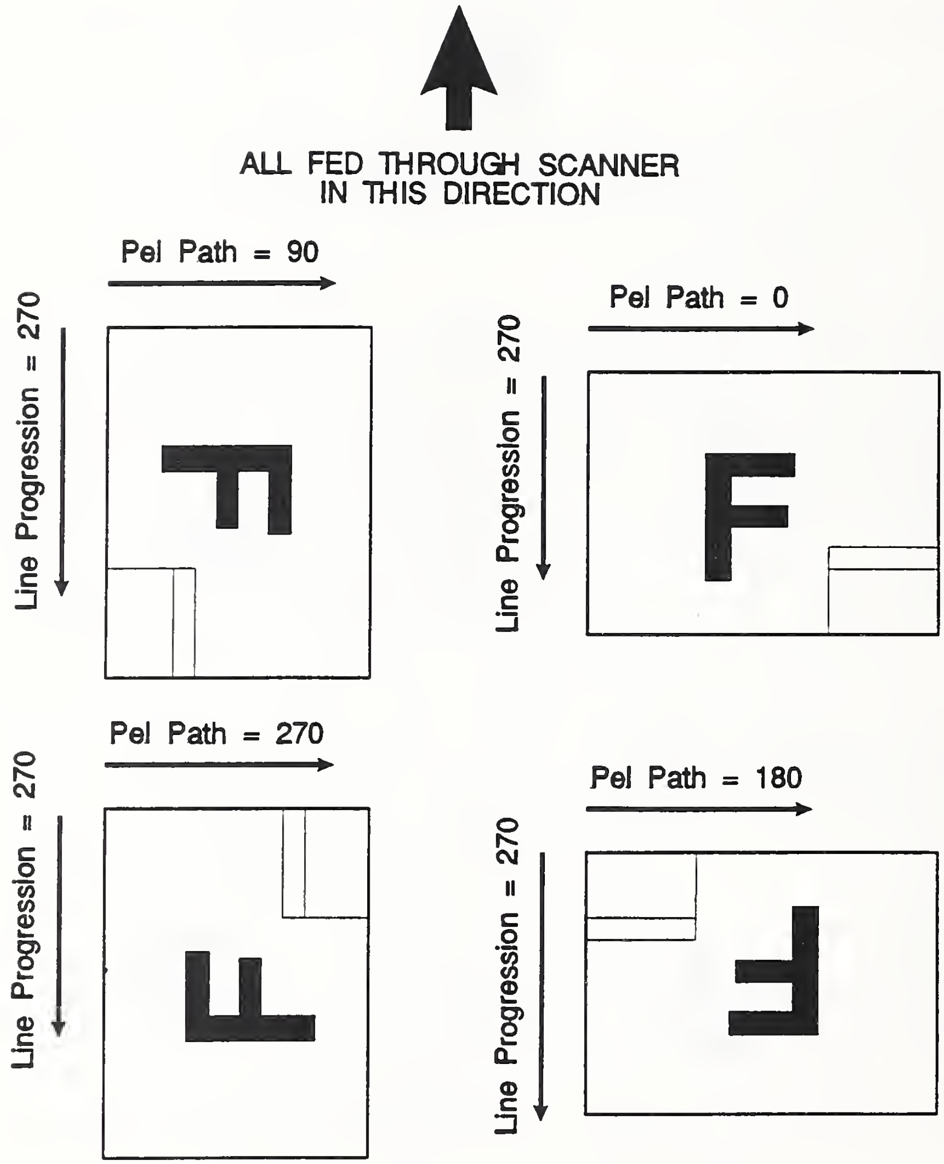
Figure 7. Position of Pels, Portrait Document



Note 1: The pel path direction is measured in degrees counterclockwise from the positive horizontal axis (east).

Note 2: The line progression direction is measured in degrees counterclockwise from the pel path direction.

Figure 8. Position of Pels, Landscape Document



Note 1: The pel path direction is measured in degrees counterclockwise from the positive horizontal axis (east).

Note 2: The line progression direction is measured in degrees counterclockwise from the pel path direction.

If a mix of scans is done as a batch and the file writer assumes all of the scans have a certain orientation when in fact they do not, then a QA post-process will be necessary. The QA operator would view each scan, check its quality, perhaps perform a clipping operation, and then identify which direction would be "up" for proper viewing orientation. The orientation parameters would end up in the file, which until that point would have had incorrect orientation parameters. No other changes or actual rotation would be required.

It is worth noting that the DAP requires all tiles to have the same orientation.

10.8 Rotation to Proper Viewing Orientation

MIL-R-28002A allows the contract to optionally specify that all documents be rotated where necessary to achieve proper viewing orientation with pel path direction set to 0 and line progression direction set to 270. If this option has been specified, the QA process described above would require an additional step of rotating any document which was improperly scanned. This contracting option would be specified in systems where the viewing subsystem is not powerful enough to perform at display time any rotation which may be required because of earlier random-orientation scanning.

10.9 Uncompressed Bit Sense

Raster data represents each pel in the source document by a zero or a one. Differing conventions exist in industry as to whether a one represents a light or a dark picture element. The situation is further confused by the existence of both photographic positive and photographic negative source documents, e.g., aperture cards, blueprints, blue lines.

MIL-R-28002A states that an uncompressed image or tile shall represent the "information" in a source document by one bits and the "background" by zero bits. The "information" pels in an image are those which make it differ from a blank image. Such pels are typically (though not necessarily) grouped into run lengths shorter (on average) than are "background" pels.

This representation assures harmony with T.6 encoding when such images or tiles are later compressed. T.6 coding best compresses short runs of ones and longer runs of zeros.

In T.6, the correct use of ones and zeros in <u>compressed</u> data is not open to confusion. It specifies the coding unambiguously.

10.10 Database Issues

In Type II files, a document may contain multiple pages (as pages are defined within ODA). These pages may contain several images of a multiple frame aperture card. They may also contain the original image and a scaled down overview image. In this latter case, the main image appears as the first page. The sheets of a multiple sheet paper drawing or multiple card aperture card drawing may also appear as pages within the same document. This requires a prior agreement between the exchanging parties or in the contracting document. This agreement identifies the allowed uses of this mechanism and how these uses are to be distinguished from each other.

10.11 Definite versus Indefinite Length

When encoding various data objects in ASN.1, a choice exists between using definite length encoding and indefinite length encoding.

Definite length encoding has an explicit length specified for an object. This applies to the entire containing object, even if it is constructed of many smaller objects. A reader that may be uninterested in the internal details of the object can safely skip ahead a known number of bytes.

This will not work for writers. A writer must have foreknowledge of the size of the entire object before even writing out any of its contained objects, which may themselves have variable sizes. An enormous stack may be required in order to buffer pending objects.

This contrasts with indefinite length encoding, where an explicit length is not given. Instead, a flag indicates the end of the object. A reader is then required to parse all the contained objects in order to not miss the flag. This slows down readers. It does, however, remove the need for a writer to have a large stack as described above. This becomes particularly important when creating interchange files containing tiled raster data. It may be more advantageous for the creator to use indefinite length encoding for the content-portion and the content-information (see **Test Chart Transfer Values**, Appendix C).

10.12 Basic versus Non-basic versus Default Values

Basic values are those commonly used values that may be placed by encoders into a parameter without any explicit statement of the intent to do so. Decoders are expected to be able to deal with all basic values.

Non-basic values are non-commonly used values which may appear in the associated parameter and must be called out by encoding programs in a section near the top of the document, well before they are used. This allows decoding programs to quickly discern if they are able to process the file. The non-basic values are specified in the non-basic-doc-characteristics portion of the document-characteristics portion of the document-profile (see **ASN.1 Definitions**, Appendix A). Decoders may not be able to support non-basic values; however, ISO encourages implementors to support both basic and non-basic values.

A value not listed as basic or non-basic is not permitted, unless it occurs via a default. This is not always as restrictive as it might seem--{ANY_VALUE} is sometimes listed as non-basic.

The defaulting mechanism operates as follows. If a parameter is not specified where it occurs, the parameter assumes the corresponding value specified for the next object up in the hierarchy of objects, e.g., tile to page, page to document. These defaults, if not stated in the document profile, are found in IS 8613.

10.13 Null Tiles

Each tile in a Type II file may be of a different type. It may be T.6 compressed, bitmapped, null foreground, or null background. A tile that has a tile type of "null background" will have a null pointer in the tile index and will be imaged as background without a need to draw raster content from the file--in fact it has none.

10.14 Presentation Styles

There are two alternatives for designating the proper presentation attributes which are to be used in presenting raster graphics information on a page. These attributes include pel-path, line-progression, clipping, and pel-spacing. As can be seen in the ASN.1 Definitions (Appendix A), the presentation attributes are used to describe the Layout-Object-Description-Body; in our case the layout object is the Basic Page. One alternative is to assign the presentation attributes (with a tag of 6) directly to the Basic Page.

A second alternative is to use a presentation style (having a tag of 17). Of course, if all the ODA default values are used then no presentation attributes will have to be designated at all. The default values for these attributes are a pel-path of 0, a line-progression of 270, a clipping rectangle marked by the two points (0,0; N-1,L-1), and a pel-spacing of 4 BMU (300 dpi).

If a document consists of only a single page or if a document has multiple pages each with one unique presentation attribute requirement, then the presentation attributes, if required, may be assigned directly to the Basic Page. The Presentation Style constituent need not be used.

If, on the other hand, a document consists of multiple pages with several pages sharing the same presentation attribute description (same pel-path, line-progression, etc.), then it would be more practical to use the Presentation Style constituent.

The use of presentation style is illustrated in Appendices B and C. Note that the style-identifier in the Interchange Data Element for Presentation Style is '5 0' and that the presentation-style attribute in Interchange Data Element for Document Layout Basic Page contains a value of '5 0'. This identifier serves as a linking mechanism between the Presentation Style constituent and the appropriate Basic Page constituent. If the document illustrated had many pages, all consisting of the same presentation characteristics, then all of the additional Basic Page descriptions would reference the same presentation style of '5 0'.

If a document consisted of many pages with three different presentation styles, then there would have to be a Presentation Style described for each: the first with a style-identifier of '5 0', the second with '5 1', and the third with '5 2'. Then each page would reference the appropriate presentation style with its presentation-style attribute containing either '5 0', '5 1', or '5 2'.

In a multiple page document, the use of presentation styles allows the user to define a set of presentation styles with each one being unique. Then a Page description refers to the appropriate presentation style. If styles are not used, then the presentation attributes would have to be repeated on every page even though they would contain identical descriptions.

11 TOOLS

11.1 Free Value tool, ASN.1 Compilers

The Free Value Tool is a set of development tools for working with ASN.1 defined protocols or profiles. It can improve the programmer's understanding of ASN.1 syntax by allowing parsing, transformation of profile structures into actual C language data structures, and conversions into and out of transfer format. Because it is highly general, it is not suited to production implementations.

The term "free value" comes from the fact that the result of running the tool is not a particular representation of one document, but rather a set of data structures and operations capable of properly encoding any of the defined class of documents. The variables of the data structure are "free" to assume any one value out of the allowed range of values.

The Free Value tool comes as part of the OSIkit which is a collection of tools for the application of Estelle and ASN.1 that were developed by NIST. Documents for these tools are distributed by the National Technical Information Service (NTIS) of the U.S. Department of Commerce. This software is not supported. The manual with the Free Value tool [5] (which is also available without the program) contains a valuable introduction to ASN.1 notation.

ASN.1 compilers are also available commercially from several vendors.

11.2 Libraries, API's

An implementor may also wish to consider simpler libraries of callable routines which write or read the objects defined in the DAP after the calling application fills in an appropriate data structure.

There is discussion within the ODA SIG of the possibility of developing applications programming interfaces (APIs) for ODA, which could lead to standardized libraries.

12 GLOSSARY

All definitions are taken IS 8613, Part 1, except where otherwise specified.

Attribute. An element of a constituent of a document that has a name and a value and that expresses a characteristic of the constituent or a relationship with one or more constituents of the document.

Constituent. A set of attributes that is one of the following types: a document profile, an object description, a presentation style, a layout style, or a content portion description.

DAP. The specification of a combination of features defined in IS 8613, intended to form a subset to fulfil the requirements of an application.

Document profile. A set of attributes which specifies the characteristics of the document as a whole.

Document layout root. The composite object of the specific layout structure at the highest level of the hierarchy.

Formatted document architecture. A form of representation of a document that allows the presentation of the document as intended by the originator and that does not support editing and (re)formatting.

Formatted processable content architecture. This is intended to be laid out, reformatted and imaged by the recipient in accordance with the originator's intent. (Part 7)

Layout characteristics. The attributes which guide the layout structure of a layout object.

Line progression direction. The direction of progression of successive lines of pels within a basic layout object.

Pel path direction. The direction of progression of successive pels along a line within the basic layout object.

Presentation attributes. Attributes which guide the format and appearance of an object's content.

Presentation style. An constituent of the document, referred to from a basic logical or layout component, which guides the format and appearance of the document content.

13 REFERENCES

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APPENDIX A ASN.1 DEFINITIONS

This appendix contains the complete listing of the ASN.1 Definitions of an implementation of the NIST ODA Raster DAP. The ASN.1 Definitions are defined in a single module referred to as "Raster Interchange Format (RIF) Module."

The ASN.1 Definitions are a subset of the ODA ASN.1 Definitions defined in IS 8613-5, IS 8613-7, and the Addendum to IS 8613-7. These definitions were developed by the National Institute of Standards and Technology using the Free Value tool. Some constructions which may seem peculiar exist in order to work around limitations in those tools such as their lack of support for macros. For example, if macros were available to process object identifiers, the commented-out line " -- { 2 8 2 7 2 } " found below could have been properly pasted in without the use of a comment.

An example of how data values for a specific document would be assigned to each of the source code attributes is found in **Test Chart Data**, Appendix B.

```
--                              Interchange Data Element
--            ASN.1 Definitions for Raster Interchange Format (RIF)

Rif-Module
DEFINITIONS  ::=
BEGIN

Interchange-Data-Element        ::=  CHOICE {
   document-profile             [0]  IMPLICIT Document-Profile-Descriptor,
   layout-object                [2]  IMPLICIT Layout-Object-Descriptor,
   content-portion              [3]  IMPLICIT Text-Unit,
   presentation-style           [7]  IMPLICIT Presentation-Style-Descriptor
                                     }

Document-Profile-Descriptor      ::= SET {
   specific-layout-structure     [1] IMPLICIT NumericString OPTIONAL,
   document-characteristics      [2] IMPLICIT Document-Characteristics OPTIONAL,
   document-management-attributes [3] IMPLICIT Document-Management-Attributes OPTIONAL,
   presentation-styles           [6] IMPLICIT NumericString OPTIONAL
                                     }

Document-Characteristics        ::=  SET {
   document-architecture-class  [1]  IMPLICIT INTEGER {
                                        formatted (0)}
                                        OPTIONAL,
   non-basic-doc-characteristics [2] IMPLICIT Non-Basic-Doc-Characteristics
                                     OPTIONAL,
   document-application-profile [4]  IMPLICIT OBJECT IDENTIFIER,
                                        -- {1 3 14 11 0 1 1},
                                        -- proposed object ID
   content-architecture-classes [5]  IMPLICIT SET OF OBJECT IDENTIFIER OPTIONAL,
                                        --  { 2 8 2 7 2 },
   interchange-format-class     [6]  IMPLICIT INTEGER {if-b (1)},
   oda-version                  [8]  IMPLICIT SEQUENCE {
      standard                          Character-Data,
      publication-date                  Date-and-Time} OPTIONAL,
   doc-appl-profile-defaults   [10]  IMPLICIT Doc-Appl-Profile-Defaults OPTIONAL
                                     }
```

```
Doc-Appl-Profile-Defaults               ::=  SET {
   document-architecture-defaults       [0]  IMPLICIT Document-Architecture-Defaults,
   raster-gr-content-defaults           [2]  IMPLICIT Raster-Gr-Content-Defaults OPTIONAL
                                             }

Document-Architecture-Defaults     ::=  SET {
   content-architecture-class      [0]  IMPLICIT Content-Architecture-Class OPTIONAL,
   page-dimensions                 [2]  IMPLICIT Measure-Pair OPTIONAL,
   medium-type                     [6]  IMPLICIT Medium-Type OPTIONAL,
   page-position                   [9]  IMPLICIT Measure-Pair OPTIONAL,
   type-of-coding                 [10]  Type-Of-Coding OPTIONAL
                                        }

Non-Basic-Doc-Characteristics      ::=  SET {
   page-dimensions                 [2]  IMPLICIT SET OF Dimension-Pair OPTIONAL,
   ra-gr-presentation-features     [4]  IMPLICIT SET OF Ra-Gr-Presentation-Feature OPTIONAL,
   medium-types                    [8]  IMPLICIT SET OF Medium-Type OPTIONAL
                                        }

Document-Management-Attributes     ::=  SET {
   document-description            [7]  IMPLICIT Document-Description OPTIONAL
                                        }

Document-Description               ::=  SET {
   document-reference              [5]  Document-Reference OPTIONAL
                                        }

Document-Reference                 ::=  CHOICE {
   unique-reference                     OBJECT IDENTIFIER,
   descriptive-reference                Character-Data
                                        }

Character-Data                     ::=  [APPLICATION 3] IMPLICIT OCTET STRING

Date-and-Time                      ::=  [APPLICATION 4] IMPLICIT PrintableString

-- LAYOUT DESCRIPTORS

Layout-Object-Descriptor           ::=  SEQUENCE {
   object-type                          Layout-Object-Type OPTIONAL,
   descriptor-body                      Layout-Object-Descriptor-Body OPTIONAL
                                        }

Layout-Object-Type                 ::=  INTEGER {
                                        document-layout-root (0),
                                        page (2)
                                        }

Layout-Object-Descriptor-Body      ::=  SET {
   object-identifier                    Object-or-Class-Identifier OPTIONAL,
   subordinates                    [0]  IMPLICIT SEQUENCE OF
                                             NumericString OPTIONAL,
   content-portions                [1]  IMPLICIT SEQUENCE OF
                                             NumericString OPTIONAL,
   position                        [3]  IMPLICIT Measure-Pair OPTIONAL,
   dimensions                      [4]  IMPLICIT Dimension-Pair OPTIONAL,
   presentation-attributes         [6]  IMPLICIT Presentation-Attributes OPTIONAL,
   user-readable-comments          [8]  IMPLICIT Comment-String OPTIONAL,
   user-visible-name              [14]  IMPLICIT Comment-String OPTIONAL,
   medium-type                    [16]  IMPLICIT Medium-Type OPTIONAL,
```

```
   presentation-style          [17] IMPLICIT Style-Identifier OPTIONAL,
   application-comments        [25] Application-Comments OPTIONAL
                                       }

Object-or-Class-Identifier     ::=  [APPLICATION 1] IMPLICIT PrintableString

Style-Identifier               ::=  [APPLICATION 5] IMPLICIT PrintableString

Comment-String                 ::=  OCTET STRING

Dimension-Pair                 ::=  SEQUENCE {
   horizontal                  [0]  IMPLICIT INTEGER,
   vertical                             CHOICE {
      fixed                             [0] IMPLICIT INTEGER,
      variable                          [1] IMPLICIT INTEGER}
                                    }

Medium-Type                    ::=  SEQUENCE {
   nominal-page-size                Measure-Pair OPTIONAL,
   side-of-sheet                    INTEGER { unspecified (0),
                                                      recto (1),
                                                      verso (2) }
                                                 OPTIONAL
                                    }

Application-Comments           ::=  SEQUENCE {
   object-appl-comm-encoding   [0]  IMPLICIT SEQUENCE OF INTEGER
                                    }

-- STYLE DESCRIPTORS

Presentation-Style-Descriptor  ::=  SET {
   style-identifier                 Style-Identifier,
   user-readable-comments      [0]  IMPLICIT Comment-String OPTIONAL,
   user-visible-name           [1]  IMPLICIT Comment-String OPTIONAL,
   presentation-attributes     [3]  IMPLICIT Presentation-Attributes OPTIONAL
                                    }

Presentation-Attributes        ::=  SET {
   content-architecture-class       Content-Architecture-Class OPTIONAL,
   raster-graphics-attributes  [1]  IMPLICIT Raster-Graphics-Attributes OPTIONAL
                                    }

Content-Architecture-Class     ::=  OBJECT IDENTIFIER
                                    -- { 2 8 2 7 2 }

-- TEXT UNITS

Text-Unit                      ::=  SEQUENCE {
   content-portion-attributes       Content-Portion-Attributes OPTIONAL,
   content-information              Content-Information OPTIONAL
                                    }

Content-Portion-Attributes     ::=  SET {
   content-identifier-layout        Content-Portion-Identifier OPTIONAL,
   type-of-coding                   Type-Of-Coding OPTIONAL,
   raster-gr-coding-attributes [2]  IMPLICIT Raster-Gr-Coding-Attributes OPTIONAL
                                    }

Content-Portion-Identifier     ::=  [APPLICATION 0] IMPLICIT PrintableString
```

```
Type-Of-Coding                  ::=  CHOICE {
     other-coding               [6]  IMPLICIT OBJECT IDENTIFIER
                                      --  { 2 8 3 7 0 or 2 8 3 7 3 or 2 8 3 7 5 }
                                      -- Other Types not used
                                     }

Content-Information             ::=  CHOICE {
             one-octet-string       OCTET STRING,
             seq-octet-string       SEQUENCE OF OCTET STRING }
             -- NOTE: Content-Information ::= OCTET STRING is defined in IS 8613-5,
             --       but an errata is being submitted to change the description to
             --       a choice to support tiled raster graphics.

-- RASTER GRAPHIC PRESENTATION ATTRIBUTES

Raster-Graphics-Attributes      ::=  SET {
   pel-path                     [0]  IMPLICIT One-Of-Four-Angles OPTIONAL,
   line-progression             [1]  IMPLICIT One-Of-Two-Angles OPTIONAL,
   clipping                     [4]  IMPLICIT Clipping OPTIONAL,
   pel-spacing                  [5]  Pel-Spacing OPTIONAL
                                     }

One-Of-Four-Angles              ::=  INTEGER {
                                     d0  (0), --  0 degrees
                                     d90 (1), -- 90 degrees
                                     d180 (2), -- 180 degrees
                                     d270 (3)  -- 270 degrees
                                     }

One-Of-Two-Angles               ::=  INTEGER {
                                     d90 (1), -- 0 degrees
                                     d270 (3) --270 degrees
                                     }

Measure-Pair                    ::=  SEQUENCE {
   horizontal                   [0]  IMPLICIT INTEGER,
   vertical                     [0]  IMPLICIT INTEGER
                                     }

Clipping                        ::=  SEQUENCE {
   first-coordinate-pair             [0] IMPLICIT Coordinate-Pair OPTIONAL,
   second-coordinate-pair            [1] IMPLICIT Coordinate-Pair OPTIONAL
                                     }

Coordinate-Pair                 ::=  SEQUENCE {
   x-coordinate                      INTEGER,
   y-coordinate                      INTEGER
                                     }

Pel-Spacing                     ::=  CHOICE {
   spacing                      [0]  IMPLICIT SEQUENCE {
      length                           INTEGER,
      pel-spaces                       INTEGER },
   null                         [1]  IMPLICIT NULL
                                     -- [1] null not used
                                     }

-- RASTER GRAPHICS CODING ATTRIBUTES

Raster-Gr-Coding-Attributes     ::=  SET {
   number-of-pels-per-line      [0]  IMPLICIT INTEGER OPTIONAL,
```

```
   number-of-lines              [1]  IMPLICIT INTEGER OPTIONAL,

   -- number-of-pels-per-tile-line [6]  IMPLICIT INTEGER OPTIONAL,
   -- number-of-pels-per-tile-line is always a constant 512
   -- number-of-lines-per-tile   [7]  IMPLICIT INTEGER OPTIONAL,
   -- number-of-lines-per-tile is always a constant 512

   tiling-offset                [8]  IMPLICIT Measure-Pair OPTIONAL,
   tile-types                   [9]  IMPLICIT SEQUENCE OF Tile-Type OPTIONAL
                                     }

Tile-Type                       ::=  INTEGER {
                                     null-background       (0),
                                     null-foreground       (1),
                                     encoded-t6            (2),
                                     bitmap                (5)
                                     }  -- T.4 not supported

-- RASTER GRAPHICS PRESENTATION FEATURES

Ra-Gr-Presentation-Feature      ::=  CHOICE {
   pel-path                     [9]  IMPLICIT One-Of-Four-Angles,
   line-progression            [10]  IMPLICIT One-Of-Two-Angles,
   pel-spacing                 [12]  Pel-Spacing
                                     }

-- RASTER GRAPHICS CONTENT DEFAULTS

Raster-Gr-Content-Defaults      ::=  SET {
   pel-path                     [0]  IMPLICIT One-Of-Four-Angles OPTIONAL,
   line-progression             [1]  IMPLICIT One-Of-Two-Angles OPTIONAL,
   pel-spacing                  [5]  Pel-Spacing OPTIONAL
                                     }

END
```

Appendix B Test Chart Data

This appendix demonstrates the insertion of specific data values for each attribute into the ASN.1 definitions as shown in Appendix A. It illustrates a test chart as seen in figure 9.

The resulting transfer values are seen in **Test Chart Transfer Values**, Appendix C.

The test chart image used was created by the CALS Test Network and was prepared and placed into the proper format by the National Institute of Standards and Technology using the Free Value tool.

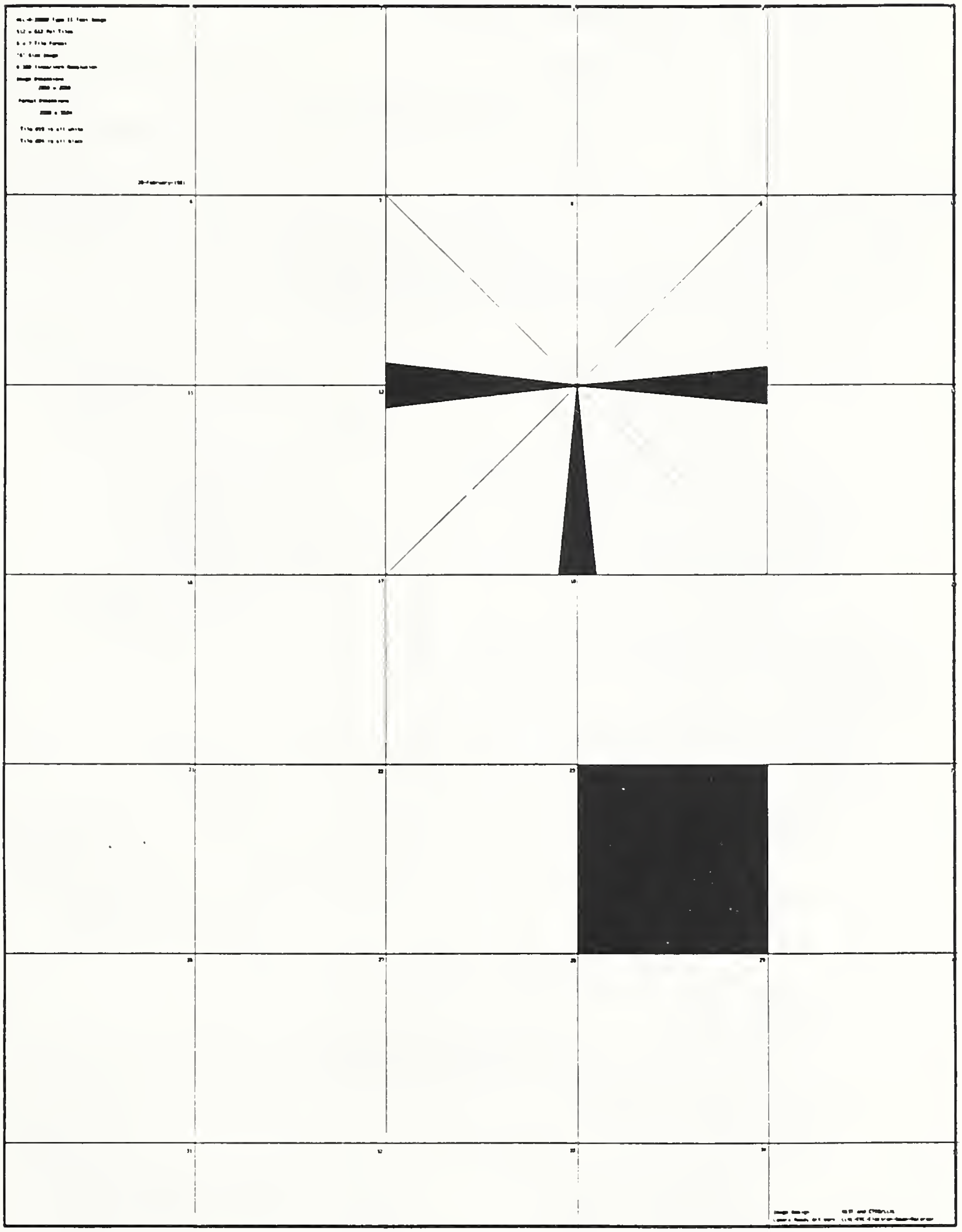
The bitmapped raster file representing the image is 2560 pels by 3584 lines and therefore has exactly 5 by 7, or 35 tiles. The image of interest is actually 2550 pels by 3300 lines which will fill an 8.5 by 11 inch page at 300 pels per inch with no margins. Within this inner image are border lines at all its edges. Since the containing bitmapped raster file comprises full tiles, there is an excess white space of 10 pels per line to the right of the inner image. Similarly, there are 284 unused (white) lines below the inner image.

In figure 9, the hard copy illustration of the test chart has been reduced for reproduction purposes.

If we imagine the tiles to be sequenced from left to right and top to bottom (the proper tile ordering according to MIL-R-28002A), every tile but 13, 14, 19, and 24 has its number rendered in text in its upper right corner.

Tile 1 contains text which displays the size in inches, the resolution in dpi, the width in pels, and the height in lines. Tile 19 is an all white tile. Tile 24 is an all black tile. Tiles 8, 9, 13, and 14 have an X between them, running from the upper left of 8 to the lower right of 14, and from the lower left of 13 to the upper right of 9. There are also 3 wedges in these 4 tiles, one between 8 and 13, one between 9 and 14, and one between 13 and 14. The 24 other tiles are mostly white with each outlined in black.

Figure 9. Test Chart



```
--                  Interchange Data Elements
--         Source Data Values for Tiled Raster Test Image
--
--         Using all possible available parameters
--         Using null tiles
-- ----------------------------------------------------------------------
--         Interchange Data Element for Document Profile

DEPRINT Interchange-Data-Element         ::=
   document-profile {
        specific-layout-structure  "1",     -- present
        presentation-styles        "1",     -- present
        document-characteristics {
          document-architecture-class 0,    -- formatted
          non-basic-doc-characteristics {
              page-dimensions { {
                        horizontal 10200,
                        vertical fixed 13200 } },
              medium-types { {
                        nominal-page-size {
                            horizontal 10200,
                            vertical 13200 },
                  side-of-sheet 0 } },      -- unspecified
              ra-gr-presentation-features {
                  pel-path         0,     -- d0
                  line-progression 3,     -- d270
                  pel-spacing spacing {
                      length 4,
                      pel-spaces 1 } } },
               document-application-profile { 1, 3, 14, 11, 0, 1, 1 },
          content-architecture-classes { { 2, 8, 2, 7, 2 } },
          interchange-format-class 1,     -- if-b
          oda-version {
              standard '49534F2038363133'H,    -- ISO 8613
              publication-date "1989-07-04" },
          doc-appl-profile-defaults {
              document-architecture-defaults {
                  content-architecture-class { 2, 8, 2, 7, 2 },
                  page-dimensions {
                     horizontal 10200,
                           vertical 13200 },
                  medium-type {
                     nominal-page-size {
                         horizontal 10200,
                               vertical 13200 },
                     side-of-sheet 0 },     -- unspecified
                  page-position {
                     horizontal 0,
                     vertical   0 },
                  type-of-coding other-coding { 2, 8 ,3, 7, 5 } },
              raster-gr-content-defaults {
                   pel-path  0,     -- d0
                   line-progression  3,     -- d270
                   pel-spacing spacing {
                       length 4,
                             pel-spaces 1 } } } },
             document-management-attributes {
           document-description {
              document-reference descriptive-reference
```

```
            '74696C696E6720746573742069606616765'H } }
            -- tiling test image
  }

 ENCODE
-- DECODE Interchange-Data-Element
ENPRINT
-- ------------------------------------------------------------------
--       Interchange Data Element for Presentation Style

DEPRINT Interchange-Data-Element ::=
   presentation-style {
      style-identifier  "5 0",
      user-visible-name  '50726573656E746174696F6E73'H,
                               -- Presentations
      user-readable-comments '5374616E64617264204465661756C742056616C756573'H,
                                -- Standard Default Values
      presentation-attributes {
         content-architecture-class { 2, 8, 2, 7, 2 },
         raster-graphics-attributes {
            pel-path  0,     -- d0
            line-progression  3,     -- d270
            clipping {
               first-coordinate-pair {
                   x-coordinate  0,
                   y-coordinate  0 },
               second-coordinate-pair {
                   x-coordinate  2549,
                   y-coordinate  3299 } },
            pel-spacing  spacing {
               length  4,
               pel-spaces  1 } } }
  }

ENPRINT
ENCODE
-- ------------------------------------------------------------------
--      Interchange Data Element for Document Layout Root

DEPRINT Interchange-Data-Element ::=
    layout-object {
       object-type  0,     -- document-layout-root
       descriptor-body {
           object-identifier  "1",
           subordinates { "0" } }
    }

ENPRINT
ENCODE
-- ------------------------------------------------------------------
--      Interchange Data Element for Document Layout Basic Page

DEPRINT Interchange-Data-Element ::=
    layout-object {
       object-type  2,
       descriptor-body {
           object-identifier  "1 0",
           content-portions { "0" },
           position {
              horizontal 0,
              vertical   0 },
```

```
            dimensions {
               horizontal 10200,
               vertical fixed 13200 },
            presentation-style  "5 0",
                 user-visible-name  '5061676520496E666F726D6174696F6E'H,
                              -- Page Information
                 user-readable-comments
                      '66756C6C20706167652035783720746696C6520666F726D6174'H,
                 -- full page 5x7 tile format
            application-comments {
               object-appl-comm-encoding {
                  4, 2016, 2174, 2336, 2495, 2739, 3018, 3166, 4896, 5648, 5876,
                  6166, 6325, 7116, 8724, 8949, 9236, 9392, 0, 9554, 9786, 10079,
                  10241, 0, 10404, 10631, 10929, 11089, 11251, 11412, 11645,
                  11871, 12037, 12204, 12370 } } }
                       -- tile index of zero indicates tile is absent (null)
      }

ENPRINT
ENCODE
-- ----------------------------------------------------------------
--      Interchange Data Element for Content Portion

DEPRINT Interchange-Data-Element ::=
   content-portion {
      content-portion-attributes {
         content-identifier-layout  "1 0 0",
         type-of-coding  other-coding { 2, 8, 3, 7, 5 },
         raster-gr-coding-attributes {
            number-of-pels-per-line  2550,
            number-of-lines          3300,
            tiling-offset {
               horizontal  0,
               vertical    0 },
            tile-types {
               2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 0,
                    2, 2, 2, 2, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2 } } },
                    -- tile 19 null-background, 24 null-foreground
      content-information seq-octet-string {
```

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   }

ENPRINT
ENCODE
```

Appendix C Test Chart Transfer Values

This appendix contains the complete listing of the transfer values of the same test chart document described in **Test Chart Data**, Appendix B.

This listing of the test chart document's transfer values was created at the National Institute of Science and Technology using the Free Value tool.

Items in angle brackets are decimal lengths. Items in square brackets are decimal tags. Items occurring in pairs are hexadecimal digits. Each pair of hexadecimal digits represents one octet. In the discussion paragraphs below, binary values are shown in parentheses.

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--             Interchange Transfer Values
--               Tiled Raster Test Image
--
--   Using all possible available parameters and null tiles

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. . . . . 80 02  [0] <2>
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.  .  91 03  [17] <3>
         35 20 30
.  .  8e 10  [14] <16>
```

```
          50 61 67 65 20 49 6e 66 6f 72
          6d 61 74 69 6f 6e
.  .  88 19  [8] <25>
          66 75 6c 6c 20 70 61 67 65 20
          35 78 37 20 74 69 6c 65 20 66
          6f 72 6d 61 74
.  .  b9 81 8f  [25] constr <143>
.  .  .  30 81 8c  [UNIV 16] constr <140>
.  .  .  .  a0 81 89  [0] constr <137>
.  .  .  .  .  02 01  [UNIV 2] <1>
                  04
.  .  .  .  .  02 02  [UNIV 2] <2>
                  07 e0
.  .  .  .  .  02 02  [UNIV 2] <2>
                  08 7e
.  .  .  .  .  02 02  [UNIV 2] <2>
                  09 20
.  .  .  .  .  02 02  [UNIV 2] <2>
                  09 bf
.  .  .  .  .  02 02  [UNIV 2] <2>
                  0a b3
.  .  .  .  .  02 02  [UNIV 2] <2>
                  0b ca
.  .  .  .  .  02 02  [UNIV 2] <2>
                  0c 5e
.  .  .  .  .  02 02  [UNIV 2] <2>
                  13 20
.  .  .  .  .  02 02  [UNIV 2] <2>
                  16 10
.  .  .  .  .  02 02  [UNIV 2] <2>
                  16 f4
.  .  .  .  .  02 02  [UNIV 2] <2>
                  18 16
.  .  .  .  .  02 02  [UNIV 2] <2>
                  18 b5
.  .  .  .  .  02 02  [UNIV 2] <2>
                  1b cc
.  .  .  .  .  02 02  [UNIV 2] <2>
                  22 14
.  .  .  .  .  02 02  [UNIV 2] <2>
                  22 f5
.  .  .  .  .  02 02  [UNIV 2] <2>
                  24 14
.  .  .  .  .  02 02  [UNIV 2] <2>
                  24 b0
.  .  .  .  .  02 01  [UNIV 2] <1>
                  00
.  .  .  .  .  02 02  [UNIV 2] <2>
                  25 52
.  .  .  .  .  02 02  [UNIV 2] <2>
                  26 3a
.  .  .  .  .  02 02  [UNIV 2] <2>
                  27 5f
.  .  .  .  .  02 02  [UNIV 2] <2>
                  28 01
.  .  .  .  .  02 01  [UNIV 2] <1>
                  00
.  .  .  .  .  02 02  [UNIV 2] <2>
                  28 a4
.  .  .  .  .  02 02  [UNIV 2] <2>
                  29 87
```

```
. . . . . . 02 02  [UNIV 2] <2>
               2a b1
. . . . . . 02 02  [UNIV 2] <2>
               2b 51
. . . . . . 02 02  [UNIV 2] <2>
               2b f3
. . . . . . 02 02  [UNIV 2] <2>
               2c 94
. . . . . . 02 02  [UNIV 2] <2>
               2d 7d
. . . . . . 02 02  [UNIV 2] <2>
               2e 5f
. . . . . . 02 02  [UNIV 2] <2>
               2f 05
. . . . . . 02 02  [UNIV 2] <2>
               2f ac
. . . . . . 02 02  [UNIV 2] <2>
               30 52

<12773>
a3 82 31 e1  [3] constr <1276f> ("OR" a3 80  [3] const <Indefinite length>)
. 31 81 8a  [UNIV 17] constr <138>
. . 40 05  [APPL 0] <5>
         31 20 30 20 30
. . 86 04  [6] <4>
         58 03 07 05
. . a2 7b  [2] constr <123>
. . . 80 02  [0] <2>
            09 f6
. . . 81 02  [1] <2>
            0c e4
. . . a8 06  [8] constr <6>
. . . . 80 01  [0] <1>
             00
. . . . 80 01  [0] <1>
             00
. . . a9 69  [9] constr <105>
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
. . . . 02 01  [UNIV 2] <1>
             02
```

```
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             00
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             01
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
. . . . . 02 01  [UNIV 2] <1>
             02
.  30 82 31 50  [UNIV 16] constr <12624> ("OR" 30 80  [UNIV 16] constr <Indefinite Length>)
. .  04 82 07 d8  [UNIV 4] <2008>  -- tile 1
       26 a4 47 03 50 6c 34 16 c8 e0 6a 1a fd 2f 64 70 35 0d 7e 97
       b2 38 1a 86 bf 42 6d 14 29 43 82 23 a5 da 48 8e 90 44 75 a1
       18 ff ff ff ff f8 41 f8 ff ff ff ff ff ff ff ff ff ff 94 88
       e2 2e 66 11 d4 c9 0c db 36 cd b3 6c 9c 64 4c cc 19 38 c8 84
       43 3f f0 c2 e5 59 47 2a ca 72 ac a7 2a ca 72 ac a7 2a ca 20
       10 61 06 10 30 58 61 7d af ff ff ff ff ff ff f8 ff ae a3 e7
       11 b4 5d 11 e3 6f f3 cc db 08 3c dc 47 cd c7 22 3a 30 fe 81
       14 38 44 75 f2 7a a6 b4 10 2e 82 23 a4 bf b3 09 15 65 11 f4
       55 94 e5 59 56 17 09 04 5d 20 46 12 04 a8 ab 29 70 af ff e7
       ca 53 a3 64 92 2a c1 69 7a 5a 5b 2a 35 ff ff 8f fe 3e ff fb
       5f 8e ca 0d 7d f7 a5 e9 7c 7f c6 cb cf f8 2f c7 ff ff a5 f5
       d6 96 c2 fe 55 7f 94 41 57 ff 45 47 e5 2e ab f1 ff 65 1d 7f
       fa 5f df 9b 5f e6 d1 75 e5 d7 ff eb 9b 5f e1 07 24 7f 25 09
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a6 a4 88 b5 40 93 41 06 10 7b 4d 34 10 7f b4 08 13 08 15 af
11 11 11 11 11 11 f1 11 11 11 11 11 11 11 c7 d2 ce c2 97 e1
05 ed 7b 58 f8 8f ff ff ff ff ff ff ff ff f9 30 47 11 c6 52
11 c4 71 94 19 22 28 19 c4 72 f9 54 a2 ac a2 65 52 8a b2 8e
55 94 1c 18 2c 3f e8 22 3a fd 04 47 5f fe 3f e3 8e 4e 8d ac
71 fc c3 f3 d6 71 9b 7f 27 d4 be 4f a9 7a 2a ca ce 1f 45 59
4e 55 94 6d fc 89 2d 26 53 a3 52 d2 93 8f ff f8 ff a4 d7 a5
2b c7 ff 1b 2c da 7c 98 5e 92 08 ba 28 5e 97 28 ff e5 10 51
b7 ff d2 49 94 7f a5 e6 d7 fe 6d 17 5f b4 10 72 47 ed 04 1c
91 ed 7f b4 d7 88 88 88 88 88 88 88 88 ff ff ff ff ff ff ff
ff ff ff ff 93 04 49 91 a0 ce 23 91 10 44 55 7c a1 a2 ae 0c
16 1e 51 57 f1 f1 ff f3 aa 36 92 cf 59 c7 99 b3 08 8f 17 88
f9 b8 20 fe 4d 1f c3 e8 ab 28 e4 e0 ab 05 61 14 38 48 22 e9
02 30 83 0b c8 92 65 3a 4b ff 95 fe 87 f1 ff da ff 8f ff f0
5f c9 85 a0 8b a4 bf 95 af ff d1 51 ff d2 65 11 ff 36 bf ff
fc ba f6 bf fd ad af f6 88 e9 af 11 11 11 11 11 11 11 11 1f
ff ff ff ff ff ff ff ff ff ff f2 04 8b a3 99 c4 5d 12 19 e4
4c 1f ff e8 ab 2b 21 85 ff ff 8f fe 82 2e bd 95 e6 b2 50 58
73 71 1f 37 1c 88 e8 c3 f1 1f 11 67 f9 9a 45 59 44 61 20 8b
a4 08 c2 40 95 15 65 1b 05 7f 0c ae a5 ff e3 ef fe 93 28 21
59 4a 3f f0 5f 8f e3 29 d7 a5 2a bf e8 a8 fc a3 65 5f 2a ff
a5 9b 5f ff ae 6d 7f b5 c9 42 08 3f da 04 09 84 0a d7 88 88
88 88 88 88 8e 3e 76 96 bf 6b c7 ff ff ff ff ff ff ff ff fc
ed 69 79 03 c8 6c db 36 c9 11 f4 91 e4 44 23 a9 93 11 d1 19
af 41 17 48 ab 29 ca b2 9c ab 28 3f fc ab 28 0b fe 93 28 ff
ff 14 87 ff 1f c2 8f ae b9 c8 da 23 c6 d9 b7 9c 8d a2 3c 6d
e4 7b cc 33 6c db cd a3 68 20 cd c7 19 84 47 bf 40 8b a0 4b
41 02 e8 22 3a c3 d9 84 8a b2 9c ab 2a d0 7b 30 91 56 0a cc
29 38 2a ca 72 ac a7 2a ca cf 86 10 74 55 82 b3 0b ff 06 0b
4b d2 fe bf c7 eb c6 b9 4e bf 1f ff fe bf da ef bf fe 36 5d
af ff d9 50 36 5c 7f ff ff f1 28 5d 75 ff ca 20 a8 ff ff ca
20 17 ff ff fe ca 82 8f ff ff f3 68 ba d2 ff 04 0b f6 0b 36
8b af fd 72 eb ff f6 9a 69 af f6 9a ff 6b fd a6 9a d8 44 74
d6 d7 f8 88 88 88 88 8a 42 22 22 22 22 22 22 22 22 23 e3 ff
ff ff ff ff ff ff ff ff ff e4 c1 92 c6 7d 12 85 e1 85 04 61
7f fb 28 dc a3 e6 e2 3e 6e 39 11 d1 87 e6 23 11 1f 36 cc 22
3c 6d 9b 8e 33 08 8f 1b 7f c2 41 17 48 11 84 81 2a 2a ca 3f
0f 09 04 5d 22 ac 15 98 48 ab 2b 28 ab 05 66 12 2a ca 36 1a
ff e3 ef ff ff f5 e3 fd 78 ff f8 2f c7 ff f1 fb 2f bf ec b3
61 bf fe 8a 8f ca d7 ff ca fe 7d 7f e7 d7 ff fe b9 b5 a5 ff
82 05 e5 d7 ff 97 5f 84 1f ed 02 04 c2 05 6a 0f fd af 6b 6b
da f1 11 11 11 c4 44 44 44 44 44 44 47 ca aa fd af 1f ff ff
ff ff ff 3b 08 cc 11 72 30 c9 86 6d 9b 66 df a2 ac a7 2b ca
f2 ac a2 65 59 4e 55 94 e5 59 4e 55 94 6c 1f ff ff ff ff 1f
f5 27 46 d0 e3 eb af a5 27 04 e2 82 23 af 04 81 2d 04 0b a0
88 eb d2 34 47 d6 96 ca 74 0c af 05 a5 e9 7e 97 de d7 df 7f
a4 79 65 d7 5a 08 ba 28 59 75 d7 5f a5 ff e9 32 8f ff ff e4
a1 34 d7 b4 d3 4d 78 88 88 88 88 8f ff ff ff ff ff ff ff ff
ff ff ff ff 91 32 22 a8 86 cf a2 50 be 51 56 08 c2 ff fd 94
6e af e6 6c c2 23 c5 e2 3e 6e 08 3f 31 18 88 f9 b6 61 11 e3
6c dc 71 98 44 78 db f9 38 2a c1 58 45 0e 12 08 ba 40 8c 20
c2 f0 f0 90 45 d2 2a c1 59 84 8a b2 b2 8a b0 56 61 22 ac a3
6a fc af f4 3f 8f ff ff d7 8f f5 e3 ff ff 82 ff ff 1f b2 fb
fe cb 36 4f ff ff 45 47 ff f9 5f cf af fc fa ff ff ff 2e b4
bf f0 40 bc ba ff f2 eb fd af f6 88 e9 a8 3f f6 bd ad af 6b
c4 44 44 44 44 44 44 44 44 44 44 47 ff ff ff ff ff ff ff ff
ff ff fc ed 23 30 46 19 b6 4c 33 04 61 9f 5e 8a b2 9c af 2a
ca 72 ac a2 65 59 4e 57 95 65 67 ff c7 ff f4 11 1d 78 ff a9
3a 36 87 fd 2f d2 93 82 71 41 11 d7 82 52 76 92 fd 23 45 2a
c1 69 6c a7 40 ca f2 9c ab 04 97 e9 7f 7b 5f f1 7e 91 e5 fd
68 22 e8 a1 65 d7 e7 97 a5 ff e9 32 8f ff ff 92 84 d3 5e d3
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        4d 7e 22 22 22 22 23 ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff fe 45 c6 71 1c 88 34 5d 1c 47 19 d1 10 28 e4 44 22
        74 79 78 30 58 7f 54 55 94 1c 38 7f ff 1f d0 44 75 e3 f8 ff
        9e b3 8c 21 63 f9 44 71 92 2f 28 40 81 64 78 dc 10 66 df e1
        f4 55 94 82 9c 2f c3 a2 ac a3 82 30 bf ec c2 0e 18 48 ab 29
        b9 6f ff ff 7f 11 ff 04 0b af ff ff 8c 21 79 a2 d9 64 7f ff
        f8 ff f9 5a 94 e1 7e 68 91 51 ff ff e5 37 52 ff e6 d7 e6 d7
        9b 5f ff ff e0 81 66 d7 fe d7 84 1b 5b 4d 11 d7 b4 12 fd a6
        bc 44 44 44 44 44 44 44 44 44 44 7f ff ff ff ff ff ff ff ff
        ff ff c8 b8 ce 23 91 06 8b a3 0c fa 3a 22 05 1c 89 08 ce 22
        17 83 05 87 f4 55 95 9c 38 7c 3f f8 ff e8 22 3a 1f ff f3 d6
        71 84 2c 74 b2 44 71 92 2f c8 f6 72 38 f3 0b f0 fa 2a ca 41
        4e 12 49 61 d1 56 51 c1 18 5f 66 16 81 18 48 ab 05 a5 ff ff
        a4 97 e2 3f d7 8f 8e 97 ff 18 42 d2 8b d9 64 7f f0 5e 3f fe
        56 a5 38 49 13 ac d1 22 a3 ff a2 a3 c2 2e bf fc da f4 bc da
        ff ef ff 04 0b 65 37 04 ff b5 f2 5d da 68 8e be 81 2d a0 40
        9a d9 4d cb 78 88 88 88 88 88 88 88 88 88 88 8f ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff f9 36 0d 90 d9 32 47 19
        b6 79 7a 2a ca d1 2a 2a ca 72 ac ab ff e8 22 3a ff 41 11 d7
        8f 9b 8d a2 3c 61 1b 46 23 68 8f 18 46 d0 ff e3 fa 5a 04 61
        58 20 5e 81 18 56 08 17 ff ff a4 6c b1 eb f1 e8 59 51 2e 5b
        bf e9 0e 0b fe 0b e9 0e 68 8f af d2 3a 2d 15 1f f4 54 76 17
        ff e9 7f fe bf fe 6d 65 d7 fc 92 13 40 81 7b 08 15 a0 40 b6
        82 0d a6 82 0f c4 44 44 44 44 47 11 11 f4 bc 20 bf 6b c7 ff
        ff ff ff f8 c0 04 00 40
.  .  04 81 9b  [UNIV 4] <155>  -- tile 2
        26 a0 6a 0a e4 e3 ff fc bb f4 55 95 11 f3 44 3e 96 96 96 96
        97 25 48 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff e4 d4 0d 81 b8 00 80 08
.  .  04 81 9f  [UNIV 4] <159>  -- tile 3
        26 a0 6a 0a c4 82 ff ff f1 35 a2 c8 a8 f4 55 95 ff c7 c1 2c
        19 5f f2 c8 a6 bf f6 b1 ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff f2 6a 06 c0 dc 00 40 04
.  .  04 81 9c  [UNIV 4] <156>  -- tile 4
        26 a0 6a 0a e6 82 ff ff f8 82 2a 95 d0 44 75 a5 e9 7a 5f 17
        96 42 45 ff 8f ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff e4 d4 0d 81 b8 00 80 08
.  .  04 81 f1  [UNIV 4] <241>  -- tile 5
        26 a0 6a 19 a5 cc cd 11 c5 c1 05 b2 38 f8 7a 5f 91 ca c8 e3
        fc ae 4b 8f b2 38 e3 8b e4 fc a1 c2 23 a9 64 2b 49 24 97 88
        b9 64 16 5f fe d7 1f ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
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          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff c9 a8 1a 82 d4 00 40
          04
 .  .  04 82 01 13  [UNIV 4] <275>  -- tile 6
          26 a4 bf ff ff ff ff f9 64 2c 7e 8a b2 a9 f1 ff e4 cf e5 59
          54 ff ff ff ed 78 ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff 18 00 80 08
 .  .  04 81 91  [UNIV 4] <145>  -- tile 7
          5f ff f2 c8 0a 5c ab e3 e9 7e 97 e9 7f e3 ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff fe 4d 40 d8
          1b 80 08 00 80
 .  .  04 82 06 be  [UNIV 4] <1726>  -- tile 8
          26 a9 59 4c 86 56 53 22 5d 94 c8 95 65 32 2d d9 4c 8b 56 53
          22 cd 94 c8 b1 65 32 12 d9 4c 84 96 53 22 ad 94 c8 a9 65 32
          29 d9 4c 8a 56 53 20 5d 94 c8 15 65 32 02 d9 4c 80 45 91 65
          32 24 2a ca 45 94 c8 4f ec a6 45 7f 65 32 2b 5b 29 90 21 56
          52 2c a6 40 7f 65 32 17 fb 29 90 47 d9 4c 82 16 ca 64 14 b2
          99 04 ec a6 41 2b 29 90 6e ca 64 1a b2 99 00 ec a6 40 2b 29
          90 c5 94 c8 92 ca 64 27 65 32 2b b2 99 14 59 4c 81 2c a6 40
          76 53 21 7b 29 90 45 94 c8 32 ca 64 4f 65 32 57 65 32 55 65
          32 6b 65 32 69 65 32 07 65 32 11 65 32 22 ca 64 3d 94 c9 4b
          29 92 76 53 27 d9 4c 9d 65 32 65 94 c9 76 53 24 59 4c 8f 65
          32 0f 65 32 1a d9 46 e6 96 51 b9 9d 94 6e 65 65 1b a5 d9 46
          e9 56 51 ba dd 94 6e b5 65 1b ac d9 46 eb 16 51 b9 2d 94 6e
          49 65 1b aa d9 46 ea 96 51 ba 9d 94 6e a5 65 1b 85 d9 46 e1
          56 51 b8 2d 94 6e 09 65 1b 96 d9 46 e5 96 51 b9 5d 94 6e 55
          65 1b 94 d9 46 e5 16 51 b8 bd 94 6e 2d 65 1b 8a d9 46 e2 96
          51 b8 9d 94 6e 25 65 1b 8d d9 46 e3 56 51 b8 1d 94 6e 05 65
          1b 98 b2 8d d2 59 46 e4 ec a3 75 76 51 ba 8b 28 dc 25 94 6e
          0e ca 37 2f 65 1b 88 b2 8d c6 59 46 e9 ec a3 7a ec a3 7a ac
          a3 7d 6c a3 7d 2c a3 70 ec a3 72 2c a3 74 59 46 e7 b2 8d e9
          65 1b ce ca 37 fb 28 df ac a3 7c b2 8d ee ca 37 8b 28 dd ec
          a3 71 ec a3 73 5b 28 d8 d2 ca 36 33 b2 8d 8c ac a3 64 bb 28
          d9 2a ca 36 5b b2 8d 96 ac a3 65 9b 28 d9 62 ca 36 25 b2 8d
          89 2c a3 65 5b 28 d9 52 ca 36 53 b2 8d 94 ac a3 60 bb 28 d8
          2a ca 36 05 b2 8d 81 2c a3 62 db 28 d8 b2 ca 36 2b b2 8d 8a
          ac a3 62 9b 28 d8 a2 ca 36 17 b2 8d 85 ac a3 61 5b 28 d8 52
          ca 36 13 b2 8d 84 ac a3 61 bb 28 d8 6a ca 36 03 b2 8d 80 ac
          a3 63 16 51 b2 4b 28 d8 9c 9a a6 51 b2 b8 b2 8d 94 59 46 c1
          2c a3 60 76 51 b1 7b 28 d8 45 94 6c 32 ca 36 4f 65 1b 57 65
          1b 55 65 1b 6b 65 1b 69 65 1b 07 65 1b 11 65 1b 22 ca 36 3d
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         94 6d 4b 28 da 76 51 b7 d9 46 dd 65 1b 65 94 6d 76 51 b4 59
         46 cf 65 1b 0f 65 1b 1a d9 4d cd 2c a6 e6 76 53 73 2b 29 ba
         5d 94 dd 2a ca 6e b7 65 37 5a b2 9b ac d9 4d d6 2c a6 e4 b6
         53 72 4b 29 ba ad 94 dd 52 ca 6e a7 65 37 52 b2 9b 85 d9 4d
         c2 ac a6 e0 b6 53 70 4b 29 b9 6d 94 dc b2 ca 6e 57 65 37 2a
         b2 9b 94 d9 4d ca 2c a6 e2 f6 53 71 6b 29 b8 ad 94 dc 52 ca
         6e 27 65 37 12 b2 9b 8d d9 4d c6 ac a6 e0 76 53 70 2b 29 b9
         8b 29 ba 4b 29 b9 3b 29 ba bb 29 ba 8b 29 b8 4b 29 b8 3b 29
         b9 7b 29 b8 8b 29 b8 cb 29 ba 7b 29 bd 76 53 7a ac a6 fa d9
         4d f4 b2 9b 87 65 37 22 ca 6e 8b 29 b9 ec a6 f4 b2 9b ce ca
         6f f6 53 7e b2 9b e5 94 de ec a6 f1 65 37 7b 29 b8 f6 53 73
         5b 29 73 4b 29 73 3b 29 73 2f b2 97 4b b2 97 4a b2 97 5b b2
         97 5a b2 97 59 b2 97 58 b2 97 25 b2 97 24 b2 97 55 b2 97 54
         b2 97 53 b2 97 52 b2 97 0b b2 97 0a b2 97 05 b2 97 04 b2 97
         2d b2 97 2c b2 97 2b b2 97 2a b2 97 29 b2 97 28 b2 97 17 b2
         97 16 b2 97 15 b2 97 14 b2 97 13 b2 97 12 b2 97 1b b2 97 1a
         b2 97 03 b2 97 02 b2 97 31 65 2e 92 ca 5c 9d 94 ba bb 29 75
         16 52 e1 2c a5 c1 d9 4b 97 b2 97 11 65 2e 32 ca 5d 3d 94 bd
         76 52 f5 59 4b eb 65 2f a5 94 b8 76 52 e4 59 4b a2 ca 5c f6
         52 f4 b2 97 9d 94 bf d9 4b f5 94 be 59 4b dd 94 bc 59 4b bd
         94 b8 f6 52 e6 b6 54 8d 2c a9 19 d9 52 32 b2 a4 97 65 49 2a
         ca 92 dd 95 25 ab 2a 4b 36 54 96 2c a9 12 d9 52 24 b2 a4 ab
         65 49 52 ca 92 9d 95 25 2b 2a 41 76 54 82 ac a9 02 d9 52 04
         b2 a4 5b 65 48 b2 ca 91 5d 95 22 ab 2a 45 36 54 8a 2c a9 0b
         d9 52 16 b2 a4 2b 65 48 52 ca 90 9d 95 21 2b 2a 43 76 54 86
         ac a9 01 d9 52 02 b2 a4 62 ca 92 4b 2a 44 ec a9 2b b2 a4 a2
         ca 90 4b 2a 40 ec a9 17 b2 a4 22 ca 90 cb 2a 49 ec a9 57 65
         4a ab 2a 5a d9 52 d2 ca 90 76 54 88 b2 a4 8b 2a 47 b2 a5 4b
         2a 53 b2 a5 f6 54 ba ca 96 59 52 bb 2a 51 65 49 ec a9 0f 65
         48 d6 ca d9 a5 95 b3 3b 2b 66 56 56 d2 ec ad a5 59 5b 5b b2
         b6 b5 65 6d 66 ca da c5 95 b2 5b 2b 64 96 56 d5 6c ad aa 59
         5b 53 b2 b6 a5 65 6c 2e ca d8 55 95 b0 5b 2b 60 96 56 cb 6c
         ad 96 59 5b 2b b2 b6 55 65 6c a6 ca d9 45 95 b1 7b 2b 62 d6
         56 c5 6c ad 8a 59 5b 13 b2 b6 25 65 6c 6e ca d8 d5 95 b0 3b
         2b 60 56 56 cc 59 5b 49 65 6c 9d 95 b5 76 56 d4 59 5b 09 65
         6c 1d 95 b2 f6 56 c4 59 5b 19 65 6d 3d 95 ba ec ad d5 65 6f
         5b 2b 7a 59 5b 0e ca d9 16 56 d1 65 6c f6 56 e9 65 6e 76 56
         fe ca df 59 5b cb 2b 77 65 6e 2c ad bd 95 b1 ec ad 9a d9 46
         96 51 9d 94 65 23 8d 94 97 90 73 75 52 92 b2 0a 0d cb 4a 5b
         c8 34 9b 8b 14 b5 90 6c 37 02 29 67 20 ca 6e 5c a5 8c 82 c1
         be 85 12 e4 0f cd f8 a2 4c 81 e1 0d 8d 0a 55 c8 1e 19 cd 96
         0a 54 c8 1e 19 66 c1 65 29 e4 0f 0d 43 62 92 94 b2 07 82 a1
         b0 91 41 79 03 c0 dc d9 59 41 59 03 c1 98 da b2 81 72 19 04
         6c 72 81 32 19 01 83 67 28 b7 21 90 0a 1b a5 14 59 90 c8 06
         a6 ea 85 15 e4 32 01 b1 b9 69 45 59 0c 80 65 6e 2a 51 4e 43
         20 16 5b 98 28 a3 21 93 b7 2e 50 be 43 24 2b 70 ca 16 c8 64
         86 76 fc 50 ae 43 24 33 17 33 28 53 21 92 1a 8b ac 14 27 90
         c9 05 55 c2 8a 12 c8 64 81 ba e5 25 0d e4 32 41 99 71 b2 86
         b2 0b 63 5d 41 40 79 05 b0 c2 f5 94 05 90 5b 02 eb d0 a3 19
         05 b0 6a 5d ca 49 90 5b 06 d9 2d 94 4f 20 b6 0c b2 54 29 5e
         41 6c 16 64 58 52 8c 81 9f 21 52 82 64 0c c2 c8 c1 40 f2 06
         61 a2 42 0a 2f 90 33 0c c9 06 50 8c 81 98 6a cb 0a 19 90 33
         05 5d 99 94 9f 20 66 07 1b 25 2a bc 81 98 33 6c 28 aa b2 06
         83 d9 41 5a e4 0d 01 7d 8d 15 a6 40 d0 0b ed 41 41 e4 0d 01
         af 75 14 46 40 d0 1b 77 42 91 90 34 05 2d 8e 51 f2 06 80 b2
         b6 55 32 06 b2 99 53 c8 1a 85 2c 2b f2 06 a1 a0 50 ae c8 1a
         86 6a 42 b3 20 6a 1a a2 0a bc 81 a8 2b 10 54 64 0d 40 e3 01
         71 1a 80 08 00 80
 . .  04 82 02 ec  [UNIV 4] <748>  -- tile 9
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         47 b2 83 a0 88 eb d2 fd 2f d2 7d 22 75 a5 e9 1f 5e 93 5a 43
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          a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5
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          a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5
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          a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5
          a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5
          a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5
          a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5
          a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a5 a4 59 3c f4 89 b9 98 63
          48 9b 92 01 8d 22 6e 5a 1a 7a 44 dc 50 15 74 89 ba b0 28 d2
          26 f5 01 fe 91 37 f0 3c 3e 91 36 33 03 c1 be 91 36 55 03 c1
          af 48 9b 16 01 e1 b7 a4 4d 84 c0 f0 37 d2 26 ca c0 f0 67 d2
          26 d5 06 40 9a 44 db 83 20 34 69 16 e6 41 90 0d 1a 45 ba a8
          64 03 66 91 6e 58 19 00 a5 a4 5b 89 06 40 2d 69 16 ea 03 24
          7a 45 be a1 92 0c 69 16 fc 19 21 97 a4 57 32 0c 90 d5 d2 2b
          aa 06 48 32 69 15 ca c3 24 16 74 8a e2 40 b6 f4 8a ea 01 6c
          1f 48 af a0 2d 81 8d 22 be 02 d8 69 e9 19 25 82 d8 2a e9 19
          2a 02 d8 13 e9 19 15 81 9a d2 32 1b 03 30 fa 46 41 00 cc 1b
          e9 19 68 06 60 d5 a4 65 80 66 1b 5a 47 69 40 66 06 fa 47 6a
          60 66 0c fa 47 65 40 68 26 91 d8 d8 1a 06 7d 23 b0 80 68 19
          ba 47 61 81 a0 36 69 1d d8 1a 02 96 91 4a 03 40 2c d2 2a 60
          6a 5a 44 a4 0d 41 8d 22 34 06 a1 97 a4 41 81 a8 6a e9 1e 03
          50 38 d0 f8 c0 04 00 40
 .  .  04 81 e1  [UNIV 4] <225>  -- tile 10
          2c 81 65 ff ff ff ff ff c6 59 01 11 c7 54 55 95 34 11 1d 7c
          7d 7e 82 23 af a5 fb fd 7f e1 06 d4 47 2c 81 65 ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff fc 9a 81 a8
          16 40 04 00 40
 .  .  04 82 01 1e  [UNIV 4] <286>  --tile 11
          26 a4 bf ff ff ff ff ff ff 96 42 94 7d 7a af a0 88 e9 04 47
          5e 38 ff ff ff ff ff fe 10 61 07 e2 3f ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
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          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
          ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff fb
          28 70 88 eb 49 25 e2 3f ff ff ff ff ff ff ff ff ff ff ff ff
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        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff e3 00 10 01
  . . 04 81 9c  [UNIV 4] <156>  -- tile 12
        5f ff ff cb 20 5a 38 f5 45 59 57 41 11 d7 e3 8f e9 7a 5e 97
        a5 e9 61 07 25 71 1f ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff fc 9a 81 b0 37 00 10 01
  . . 04 82 03 13  [UNIV 4] <787>  -- tile 13
        23 81 a8 33 f2 06 a0 71 80 96 40 d4 36 f5 5c 81 a8 69 83 5c
        81 a8 65 01 a5 90 35 02 05 97 20 6a 20 22 e4 0d 52 aa e4 0d
        00 a1 2d 72 06 80 c9 b8 5c 81 a0 6b ed 0b 90 34 06 9d a7 5c
        81 a0 37 d9 35 c8 1a 03 ec 49 72 06 87 b2 a4 b2 06 60 59 b5
        25 c8 19 81 26 d6 57 20 66 1b 72 35 5c 81 98 69 cb d7 20 66
        19 52 d5 72 06 60 44 81 ae 40 cc 49 01 ae 40 cd 48 59 72 0b
        60 51 20 45 c8 2d 83 24 95 52 c8 2d 86 bc 92 d7 20 b6 0d 2b
        c2 e4 16 c1 ba e8 5c 82 d8 3a e9 d7 20 b6 6b 93 5c 86 48 2d
        2e 24 b9 0c 90 24 5c a9 72 19 20 a8 b8 5a e4 32 43 4d 75 95
        c8 64 86 5a e6 89 64 32 40 86 fe b9 0c 90 8d f4 5c 86 4a 6e
        0d 72 19 00 b0 dc 09 72 19 00 c8 dc 59 72 19 00 d8 dc b5 72
        19 00 d2 dd 55 72 19 00 a1 ba 52 e4 32 01 cd a1 72 19 04 6c
        74 b2 07 82 d1 b2 75 c8 1e 04 86 c4 d7 20 78 2a 1b 09 2e 40
        f0 d3 36 2a 5c 81 e1 96 6c 16 b9 03 c0 83 65 95 c8 1e 10 d8
        d1 72 07 a3 7f 5c 82 c1 be 8b 90 64 37 06 96 41 b0 dc 09 72
        0d 26 e2 cb 90 50 6e 5a b9 07 37 55 5c 91 ba 52 c5 2d 2d 2d
        2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b 49 52 d2 d2 d2 d2 d2 d2 d2
        d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 b4 95 2d 2d 2d 2d 2d 2d 2d
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        d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 b4 95 2d 2d 2d 2d 2d 2d
        2d 2d 2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b 49 52 d2 d2 d2 d2 d2
        d2 d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 b4 95 2d 2d 2d 2d 2d
        2d 2d 2d 2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b 49 52 d2 d2 d2 d2
        d2 d2 d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 b4 95 2d 2d 2d 2d
        2d 2d 2d 2d 2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b 49 52 d2 d2 d2
        d2 d2 d2 d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 95 2d 2d 2d 2d
        2d 2d 2d 2d 2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b 49 52 d2 d2 d2
        d2 d2 d2 d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 b4 95 2d 2d 2d
        2d 2d 2d 2d 2d 2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b 49 52 d2 d2
        d2 d2 d2 d2 d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 b4 95 2d 2d
        2d 2d 2d 2d 2d 2d 2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b 49 52 d2
        d2 d2 d2 d2 d2 d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 b4 95 2d
        2d 2d 2d 2d 2d 2d 2d 2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b 49 52
        d2 d2 d2 d2 d2 d2 d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 b4 95
        2d 2d 2d 2d 2d 2d 2d 2d 2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b 49
        52 d2 d2 d2 d2 d2 d2 d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4 b4
        95 2d 2d 2d 2d 2d 2d 2d 2d 2d 25 4b 4b 4b 4b 4b 4b 4b 4b 4b
        49 52 d2 d2 d2 d2 d2 d2 d2 d2 d2 54 b4 b4 b4 b4 b4 b4 b4 b4
        b4 95 2d 2d 2d 2d 2d 2d 2d 2d 2d 25 4b 4b 4b 4b 49 d2 2c 86
        6a 40 90 78 00 80 08
  . . 04 82 06 44  [UNIV 4] <1604>  -- tile 14
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        52 57 d9 5b bf b2 b6 1f d9 5b 07 f6 56 c6 be ca d9 57 d9 5b
        53 fb 2b 69 5e d9 52 bf b2 a4 1f d9 52 07 f6 54 86 fe ca 91
        57 d9 52 53 fb 2a 49 5f 65 2f 7f 65 2f a7 d9 4b 84 f6 ca 5c
        6f ec a5 ca be ca 5d 4f ec a5 d2 be ca 6f 9f 65 37 d3 ec a6
        e1 3e ca 6e 37 f6 53 72 af b2 9b aa 7b 65 37 4b fb 28 db 3e
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ca 36 d3 ec a3 60 9f 65 1b 0d fd 94 6c 57 f6 51 b2 a7 d9 46
c9 7f 65 1b e7 d9 46 fa 7b 65 1b a8 fb 28 dc 4b ec a3 72 bf
b2 8d d5 3e ca 37 4b fb 29 93 3e ca 64 23 b2 99 11 d9 4c 87
ec a6 4a 6d 94 c9 3e ca 64 fe ca 64 ee ca 64 ce ca 64 be ca
64 8e ca 64 7e ca 64 1f b2 99 0d 7b 28 dc d3 6c a3 73 3e ca
37 32 ec a3 74 be ca 37 4a ec a3 75 be ca 37 5a ec a3 75 9e
ca 37 58 ec a3 72 5e ca 37 24 db 28 dd 57 b2 8d d5 3b 28 dd
4f b2 8d d4 bb 28 dc 2f b2 8d c2 bb 28 dc 17 b2 8d c1 3b 28
dc b7 b2 8d cb 36 ca 37 2b ec a3 72 ae ca 37 29 ec a3 72 8e
ca 37 17 ec a3 71 6e ca 37 15 ec a3 71 4e ca 37 13 ec a3 71
2d b2 8d c6 fb 28 dc 6b b2 8d c0 fb 28 dc 0b b2 8d cc 76 51
ba 4e ca 37 27 d9 46 ea fb 28 dd 47 65 1b 84 db 28 dc 1f 65
1b 97 ec a3 71 1d 94 6e 33 b2 8d d3 f6 51 bd 7d 94 6f 57 65
1b eb d9 46 fa 76 51 b8 7b 65 1b 91 d9 46 e8 ec a3 73 f6 51
bd 3b 28 de 7d 94 6f fd 94 6f dd 94 6f 9d 94 6f 7d 94 6f 1b
65 1b bf 65 1b 8f d9 46 e6 bd 94 6c 69 d9 46 c6 7d 94 6c 65
d9 46 c9 7d 94 6c 95 d9 46 cb 7d 94 6c b5 b6 51 b2 cf 65 1b
2c 76 51 b1 2f 65 1b 12 76 51 b2 af 65 1b 2a 76 51 b2 9f 65
1b 29 76 51 b0 5f 65 1b 05 6d 94 6c 0b d9 46 c0 9d 94 6c 5b
d9 46 c5 9d 94 6c 57 d9 46 c5 5d 94 6c 53 d9 46 c5 1d 94 6c
2f d9 46 c2 db 65 1b 0a f6 51 b0 a7 65 1b 09 f6 51 b0 97 65
1b 0d f6 51 b0 d7 65 1b 01 f6 51 b0 17 65 1b 18 ec a3 64 9b
65 1b 13 ec a3 65 7d 94 6c a3 b2 8d 82 76 51 b0 3e ca 36 2f
d9 46 c2 3b 28 d8 67 65 1b 27 db 28 da be ca 36 ab b2 8d b5
ec a3 6d 3b 28 d8 3e ca 36 23 b2 8d 91 d9 46 c7 ec a3 6a 76
51 b4 f6 ca 36 fe ca 36 ee ca 36 ce ca 36 be ca 36 8e ca 36
7e ca 36 1f b2 8d 8d 7b 29 b9 a7 65 37 33 db 29 b9 97 65 37
4b ec a6 e9 5d 94 dd 6f b2 9b ad 76 53 75 9e ca 6e b1 d9 4d
c9 7b 29 b9 27 65 37 55 db 29 ba a7 65 37 53 ec a6 ea 5d 94
dc 2f b2 9b 85 76 53 70 5e ca 6e 09 d9 4d cb 7b 29 b9 67 65
37 2b db 29 b9 57 65 37 29 ec a6 e5 1d 94 dc 5f b2 9b 8b 76
53 71 5e ca 6e 29 d9 4d c4 fb 29 b8 97 65 37 1b db 29 b8 d7
65 37 03 ec a6 e0 5d 94 dc c7 65 37 49 d9 4d c9 f6 53 75 7d
94 dd 47 65 37 09 d9 4d c1 ed 94 dc bf 65 37 11 d9 4d c6 76
53 74 fd 94 de be ca 6f 57 65 37 d7 b2 9b e9 d9 4d c3 ec a6
e4 6d 94 dd 1d 94 dc fd 94 de 9d 94 de 7d 94 df fb 29 bf 76
53 7c ec a6 f7 d9 4d e3 b2 9b be d9 4d c7 ec a6 e6 bd 94 b9
a7 65 2e 67 d9 d7 4b e1 94 ba 57 65 2e b7 d9 4b ad 76 52 eb
3d 94 ba c6 d9 4b 92 f6 52 e4 9d 94 ba af 65 2e a9 d9 4b a9
f6 52 ea 5d 94 b8 5f 65 2e 15 d9 4b 82 f6 52 e0 9b 65 2e 5b
d9 4b 96 76 52 e5 7d 94 b9 57 65 2e 53 d9 4b 94 76 52 e2 fd
94 b8 b7 65 2e 2b d9 4b 8a 6d 94 b8 9f 65 2e 25 d9 4b 8d f6
52 e3 5d 94 b8 1f 65 2e 05 d9 4b 98 ec a5 d2 76 52 e4 fb 29
75 7b 65 2e a3 b2 97 09 d9 4b 83 ec a5 cb f6 52 e2 3b 29 71
9d 94 ba 7e ca 5e be ca 5e ae ca 5f 5d b2 97 d3 b2 97 0f b2
97 23 b2 97 47 65 2e 7e ca 5e 9d 94 bc fb 29 7f ec a5 fb b2
97 cd b2 97 be ca 5e 3b 29 77 ec a5 c7 ec a5 cd 7b 2a 46 9d
95 23 3e ca 91 97 65 49 2f b2 a4 95 b6 54 96 fb 2a 4b 5d 95
25 9e ca 92 c7 65 48 97 b2 a4 49 d9 52 55 ec a9 2a 76 54 94
fb 2a 4a 5b 65 48 2f b2 a4 15 d9 52 05 ec a9 02 76 54 8b 7b
2a 45 9d 95 22 be ca 91 57 65 48 a7 6c a9 14 76 54 85 fb 2a
42 dd 95 21 5e ca 90 a7 65 48 4f b2 a4 25 d9 52 1b ec a9 0d
76 54 80 f6 ca 90 17 65 48 c7 65 49 27 65 48 9f 65 49 5f 65
49 47 65 48 27 65 48 1f 65 48 bf 65 48 46 d9 52 19 d9 52 4f
d9 52 af b2 a5 57 65 4b 5e ca 96 9d 95 20 fb 2a 44 76 54 91
d9 52 3e d9 52 a7 65 4a 7d 95 2f ec a9 77 65 4b 3b 2a 57 d9
52 8e ca 93 f6 54 87 ec a9 1a ed 95 b3 4e ca d9 9f 65 6c cb
b2 b6 97 d9 5b 4a ec ad ad f6 56 d6 bb 2b 6b 3d 95 b5 8e ca
d9 2e d9 5b 24 ec ad aa f6 56 d5 3b 2b 6a 7d 95 b5 2e ca d8
5f 65 6c 2b b2 b6 0b d9 5b 04 ec ad 96 ed 95 b2 ce ca d9 5f
65 6c ab b2 b6 53 d9 5b 28 ec ad 8b f6 56 c5 bb 2b 62 bd 95
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        b1 4e ca d8 9e d9 5b 12 ec ad 8d f6 56 c6 bb 2b 60 7d 95 b0
        2e ca d9 8e ca da 4e ca d9 3e ca da be ca da 8d b2 b6 13 b2
        b6 0f b2 b6 5f b2 b6 23 b2 b6 33 b2 b6 9f b2 b7 5f 65 6e ae
        ca de bd 95 bd 36 ca d8 7d 95 b2 3b 2b 68 ec ad 9f b2 b7 4e
        ca dc fb 2b 7f d9 5b ee ca de 76 56 ef 6c ad c7 65 6d fb 2b
        63 f6 56 cd 7b 28 d3 b2 8c fb 28 cb b2 92 fb 29 2b b2 96 f6
        ca 5a ec a5 9e ca 58 ec a2 5e ca 24 ec a5 5e ca 54 ec a5 3e
        ca 52 ec a0 bd b2 82 bb 28 17 b2 81 3b 28 b7 b2 8b 3b 28 af
        b2 8a bb 28 a7 b2 8a 3b 28 5f 6c a1 6e ca 15 ec a1 4e ca 13
        ec a1 2e ca 1b ec a1 ae ca 03 ec a0 2e ca 31 b6 52 4e ca 27
        d9 4a fb 29 47 65 04 ec a0 7d 94 5f b2 84 76 50 ce ca 4f b6
        55 7d 95 57 65 6b d9 5a 76 50 7d 94 47 65 23 b2 8f d9 54 ec
        a9 ed 95 fd 95 dd 95 9d 95 7d 95 1d 82 e9 85 8b 93 50 36 06
        e0 02 00 20
.  .  04 81 de  [UNIV 4] <222>  -- tile 15
        2c 81 65 ff ff ff 1c b2 02 a3 65 59 44 20 88 eb 8f f9 39 e6
        8b fc da ff c2 0d a8 8c b2 05 97 ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
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        ff ff ff ff ff ff ff ff ff ff ff ff ff fc 9a 81 a8 2d 40 04
        00 40
.  .  04 82 01 1b  [UNIV 4] <283>  -- tile 16
        26 a4 bf ff ff ff ff ff ff f9 64 28 47 1f aa 2a ca fe 82 23
        ac 7c 7f f9 39 fe 55 95 ff ff ff ff f0 83 6b c4 7f ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff 8c
        00 40 04
.  .  04 81 99  [UNIV 4] <153>  -- tile 17
        5f ff ff 2c 81 48 d9 6b 2a fa 08 8e 87 c7 4b ff 4b ff 4b fc
        20 fc 47 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff c9 a8 1b 03 70 01 00 10
.  .  04 81 9f  [UNIV 4] <159>  -- tile 18
        5f ff ff 2c 81 68 e3 d5 15 65 5d 04 47 5f 8f fe d7 a2 ac ab
        ff ff ff 84 1b 58 8f ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff 93 50 27 23 81 a8 a0 02 00 20
```

```
      <NOTE:  Tile 19 is null-background and is not present.>
. .   04 81 e5  [UNIV 4] <229>  -- tile 20
         2c 81 65 ff ff ff ff ff ff ff 8e 59 0b 59 b7 45 59 4e 55 95
         ff f1 f5 a5 a0 88 ea 96 97 4a fa 55 d2 fc 94 28 8c b2 05 97
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff e3 96 40 b2
         ff c9 a8 1a 82 d4 00 40 04
. .   04 82 01 21  [UNIV 4] <289>  -- tile 21
         26 a4 bf ff ff ff f9 64 2b 67 97 a2 ac ab ff a0 88 eb c7 1f
         d2 fd 2f d2 fd 2f d2 fe 4a 03 f1 1f ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff e5 0e 08 8f ed 20
         88 eb 42 3f ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff e3 00 10 01
. .   04 81 9f  [UNIV 4] <159>  -- tile 22
         5f ff ff f2 c8 5a cd bd 15 65 39 56 57 7f f1 c7 d2 4b 49 2d
         24 b4 92 d2 4b 92 72 5d 11 ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff 26 a0 6c 0d c0 04 00 40
. .   04 81 a0  [UNIV 4] <160>  -- tile 23
         5f ff ff 2c 85 8c db d1 56 53 95 65 7f ff 1c 7d 20 4b 48 19
         5f 4b d2 3c bd 2f e4 a1 62 3f ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff fe 4d 40 d8 1b 80 08 00 80
      <NOTE:  Tile 24 is null-background and is not present.>
. .   04 81 e0  [UNIV 4] <224>  -- tile 25
         2c 81 65 ff ff ff ff 8c b2 15 b3 05 45 59 4e 56 9f c7 e9 49
         9d 23 45 4b a4 79 74 bf 25 0a 23 2c 81 65 ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff c9 a8 1a 81
```

```
         64 00 40 04
. .   04 82 01 26  [UNIV 4] <294>  -- tile 26
         26 a4 be ca 1c 22 3a d2 49 2e 22 ff ff ff ff cb 20 b3 36 fd
         15 65 39 56 57 ff c7 c7 fd 29 39 f4 a5 59 5f d2 ff 4b fd 2f
         f9 28 5e 23 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff c8 66 8f 00 10 01
. .   04 81 9d  [UNIV 4] <157>  -- tile 27
         50 a1 ff ff 2c 80 8c c1 68 ab 29 ca bf e3 e3 a5 a5 e9 25 a5
         e9 25 a5 f2 57 c4 7f ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff da ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff e4 d4 0d 81 b8 00 80 08
. .   04 81 9f  [UNIV 4] <159>  -- tile 28
         5f ff ff f2 c8 08 cd bd 15 65 39 56 56 7f f1 ff 49 ad 24 55
         95 94 bf 4b f4 bf 92 85 88 ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff 93 50 36 06 e0 02 00 20
. .   04 81 9e  [UNIV 4] <158>  -- tile 29
         5f ff ff 2c 85 6c db d1 56 53 95 65 4f ff 8f fa 5f a4 fa 44
         eb 4b d2 3e be 4a 16 23 ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff e4 d4 0d 81 b8 00 80 08
. .   04 81 e6  [UNIV 4] <230>  -- tile 30
         2c 81 65 ff ff ff e3 2c 8a 8e 59 0a d1 b4 8a b2 a7 ff 1f 58
         25 a0 88 ea 0c 16 97 ef 96 42 b5 d7 ff b4 d4 46 59 02 cb ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
         ff fe 4d 40 d4 19 e0 02 00 20
. .   04 81 df  [UNIV 4] <223>  -- tile 31
         26 a4 bf ff ff ff ff ff ff ff 96 41 56 79 7a 2a ca bf fa 08
         8e bc 71 fc 12 fc 19 59 ff f2 c8 28 bf ff f6 82 0f c4 7f ff
         ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
```

```
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff f9 43 82 23 ad a4
        88 eb 42 3e 3f fc b2 1a 2f ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff c0
        04 00 40
.  .  04 81 a3  [UNIV 4] <163>  -- tile 32
        5f ff ff ff f2 c8 52 cd bd 15 65 39 56 51 ff f8 e3 e0 92 58
        32 b1 7a 59 64 28 5a 5f a5 b5 24 78 8f ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff e4 d4 0d 81 bf fe 59 0d 17 ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff fe fe
        00 20 02
.  .  04 81 a4  [UNIV 4] <164>  -- tile 33
        5f ff ff fc b2 15 b3 6f 45 59 4e 55 95 3f fe 38 f8 24 09 60
        ca f2 a7 fc b2 15 2c ba ff fd a6 b1 1f ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff 26 a0 6c 0d ff f2 c8 68 bf ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        7c 00 40 04
.  .  04 81 a3  [UNIV 4] <163>  -- tile 34
        5f ff ff 2c 85 8c fa d1 56 56 7f 41 11 d6 3a 5e 09 25 e0 c1
        25 fc 5e 59 0a d6 79 7f ed 78 8f ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        fe 4d 40 d8 1b ff e5 90 d1 7f ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff fe ff 80
        08 00 80
.  .  04 82 00 ff  [UNIV 4] <255>  -- tile 35
        96 40 b2 ff ff ff ff ff ff fe 32 c8 5a cc 15 15 65 39 44 7f
        1f 82 52 73 06 57 95 ff 2c 85 8b 2e bf fd a6 a2 32 c8 16 5f
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff e4 d8 09 1b 45 cc db 2e 32 86 5c 65 d1 b4 4e 8f
        a3 e8 da 2e bd e1 84 8a b2 ac 12 2a ca b0 57 fd ff ff ff ff
        ff f4 08 17 b2 a7 c7 a0 40 bf a0 40 bf ff b3 f7 ff ff ff b0
        bc 32 b2 70 bf 61 65 cb f6 17 ff f6 55 c7 ff 1f ff fb e7 17
        e6 d7 bf ef ff ff ff ff ff b8 41 b5 b5 ef 24 e4 9e f2 40 98
        88 88 88 88 88 88 8f ff fe 4d 40 d4 0e 3f ff c7 ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
        ff ff ff ff ff ff ff ff ff ff ff c0 04 00 40
(.  00 00  <If content-information is encoded as indefinite length>)
(00 00  <If content_portion is encoded as indefinite length>)
```

Appendix D Test Chart Data, Simplest Form

This appendix represents the same test document source data values seen in **Test Chart Data**, Appendix B, but uses a minimal representation of parameters.

```
--                          Interchange Data Elements
--             Source Data Values for Tiled Raster Test Image
--
--             Using minimum set of parameters
--  --------------------------------------------------------------------
--                  Interchange Data Element for Document Profile

DEPRINT Interchange-Data-Element         ::=
   document-profile {
        specific-layout-structure  "1",      -- present
        document-characteristics {
          document-architecture-class 0,    -- formatted
               document-application-profile { 1, 3, 14, 11, 0, 1, 1 },
          content-architecture-classes { { 2, 8, 2, 7, 2 } },
          interchange-format-class 1,     -- if-b
          oda-version {
              standard '49534F2038363133'H,    -- ISO 8613
              publication-date "1989-07-04" },
          doc-appl-profile-defaults {
              document-architecture-defaults {
                  content-architecture-class { 2, 8, 2, 7, 2 },
                  type-of-coding other-coding { 2, 8 ,3, 7, 5 } } } },
             document-management-attributes {
           document-description {
              document-reference descriptive-reference
                 '74696C696E6720746573742069606616765'H } }
                 -- tiling test image
   }

 ENCODE
-- DECODE Interchange-Data-Element
ENPRINT
-- ---------------------------------------------------------------------
--             Interchange Data Element for Document Layout Root

DEPRINT Interchange-Data-Element ::=
    layout-object {
       object-type  0,     -- document-layout-root
       descriptor-body {
           object-identifier  "1",
           subordinates { "0" } }
    }

ENPRINT
ENCODE
--             Interchange Data Element for Document Layout Basic Page

DEPRINT Interchange-Data-Element ::=
    layout-object {
       object-type  2,     -- basic page
       descriptor-body {
           object-identifier  "1 0",
           content-portions { "0" } }
    }

ENPRINT
```

```
ENCODE
-- ----------------------------------------------------------------------
--           Interchange Data Element for Content Portion

DEPRINT Interchange-Data-Element ::=
   content-portion {
      content-portion-attributes {
         content-identifier-layout  "1 0 0",
         type-of-coding  other-coding { 2, 8, 3, 7, 5 },
         raster-gr-coding-attributes {
            number-of-pels-per-line  2550,
            number-of-lines          3300 } },
                  -- all tiles encoded-t6
      content-information seq-octet-string {
            -- content information is same as shown in Appendix B
      }
   }

ENPRINT
ENCODE
```

Appendix E Test Chart Transfer Values, Simplest Form

This appendix shows the transfer values for the test document whose source data values are seen in **Test Chart Data, Simplest Form**, Appendix D.

```
--                  Interchange Transfer Values
--                      Tiled Raster Test Image
--
--               Using minimum set of parameters

<96>
a0 5e  [0] constr <94>
.  81 01  [1] <1>
      31
.  a2 40  [2] constr <64>
.  .  81 01  [1] <1>
         00
.  .  84 06  [4] <6>
         2b 0e 0b 00 01 01
.  .  a5 06  [5] constr <6>
.  .  .  06 04  [UNIV 6] <4>
            58 02 07 02
.  .  86 01  [6] <1>
         01
.  .  a8 16  [8] constr <22>
.  .  .  43 08  [APPL 3] <8>
            49 53 4f 20 38 36 31 33
.  .  .  44 0a  [APPL 4] <10>
            31 39 38 39 2d 30 37 2d 30 34
.  .  aa 10  [10] constr <16>
.  .  .  a0 0e  [0] constr <14>
.  .  .  .  80 04  [0] <4>
               58 02 07 02
.  .  .  .  aa 06  [10] constr <6>
.  .  .  .  .  86 04  [6] <4>
                  58 03 07 05
.  a3 17  [3] constr <23>
.  .  a7 15  [7] constr <21>
.  .  .  a5 13  [5] constr <19>
.  .  .  .  43 11  [APPL 3] <17>
               74 69 6c 69 6e 67 20 74 65 73
               74 20 69 6d 61 67 65

<15>
a2 0d  [2] constr <13>
.  02 01  [UNIV 2] <1>
      00
.  31 08  [UNIV 17] constr <8>
.  .  41 01  [APPL 1] <1>
         31
.  .  a0 03  [0] constr <3>
.  .  .  12 01  [UNIV 18] <1>
            30

<17>
a2 0f  [2] constr <15>
.  02 01  [UNIV 2] <1>
      02
.  31 0a  [UNIV 17] constr <10>
.  .  41 03  [APPL 1] <3>
         31 20 30
```

```
. . a1 03  [1] constr <3>
. . . 12 01  [UNIV 18] <1>
         30

<12865>
a3 82 32 3d  [3] constr <12861> ("OR" a3 80 [3] constr <Indefinite length>)
. 31 17  [UNIV 17] constr <23>
. . 40 05  [APPL 0] <5>
      31 20 30 20 30
. . 86 04  [6] <4>
      58 03 07 05
. . a2 08  [2] constr <8>
. . . 80 02  [0] <2>
         09 f6
. . . 81 02  [1] <2>
         0c e4
. 30 82 32 20  [UNIV 16] constr <12832> ("OR" 30 80 [UNIV 16] constr <Indefinite length>)
. . -- tiles 1 through 18 are encoded the same as shown in Appendix C
. . 04 43  [UNIV 4] <67>  -- tile 19
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff 00 10 01
. . -- tiles 20 through 23 are encoded the same as shown in Appendix C
. . 04 81 87  [UNIV 4] <135>  -- tile 24
      26 a0 6c 0d ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff 00 10 01
. . -- tiles 25 through 35 are encoded the same as shown in Appendix C
(. 00 00  <If content-information is encoded as indefinite length>)
(00 00  <If content_portion is encoded as indefinite length>)
```

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11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

This report examines the technical issues facing an implementor of the raster data interchange form as defined in military specification MIL-R-28002A. Information previously scattered throughout several standards is incorporated into this report for ease of reference. The National Institute of Standards and Technology Office Document Architecture Raster Document Application Profile (NIST ODA Raster DAP) is analyzed with regard to both notation and intent.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

Abstract Syntax Notation One; ASN.1; CALS; DAP; document application profile; image compression; image encoding; image interchange; ODA; Office Document Architecture; raster; tiled raster data.

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