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NCS TIB 92-10



NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN 92-10

COLOR TEST CHART FOR FACSIMILE

AUGUST 1992

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August 1992

Final

Color Test Chart for Facsimile

C-DCA100-91-C-0031

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NCS TIB 92-10

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The CCITT has standardized Group 4 facsimile, and has reached agreement on adding higher resolutions to 400 pels per inch to Group 3 Facsimile. In order to measure and verify the quality of transmission for Group 4 apparatus and the advanced resolution Group 3 apparatus, it is necessary to have a standard test chart. The purpose of this project was to complete and obtain reproducible masters and evaluation prints of the printed color chart, and to define the layout and content of the photographically reproduced chart. This report is comprised of four sections. Section 1 provides a brief description of the objective of the study and an outline of the contents of this report. Section 2 discusses the steps taken to produce the final version of the color chart. Section 3 contains the description of the color chart and a guide to its use. Section 4 is a summary of the work performed.

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Facsimile		Color Test Chart	
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Unclassified	Unclassified	Unclassified	Unlimited

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COLOR TEST CHART FOR FACSIMILE

AUGUST 1992

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FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents and overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of facsimile. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:

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**COLOR TEST CHART
FOR
FACSIMILE**

August, 1992

**DRAFT
FINAL REPORT
DCA100-91-C-0031
Modification P00003**

**Submitted to:
NATIONAL COMMUNICATIONS SYSTEM
WASHINGTON, DC**

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1. INTRODUCTION

This document summarizes work performed by Delta Information Systems, Inc. (DIS) for the National Communications System (NCS), Office of Technology and Standards. This office is responsible for the management of the Federal Telecommunications Standards Program, which develops telecommunications standards, whose use is mandatory for all Federal departments and agencies. The purpose of this project, performed under contract number DCA100-91-C-0031, was to complete the printed color test chart that was begun under a previous task.¹

The CCITT has standardized Group 4 facsimile, and has reached agreement on adding higher resolutions to 400 pels per inch to Group 3 facsimile. In order to measure and verify the quality of transmission for Group 4 apparatus and the advanced resolution Group 3 apparatus, it is necessary to have a standard test chart. The NCS has been a leader in the development and promulgation of standardized imagery for facsimile. The NCS sponsored the digitizing of standard documents at resolutions of 200, 240, 300, 400, and 480 lines per inch. This data has been used by many experimenters in the development of standard compression algorithms for digital facsimile, and has contributed significantly to the development of the Group 4 recommendations which will be of considerable value to the U.S. Government. In addition, the NCS sponsored the preparation of standard gray scale images, representative of continuous tone pictures to be transmitted through facsimile systems.

The digital transmission of color imagery is of particular importance to the Government for transmission of photographs, half tones, and maps and fingerprints. The CCITT is now in the process of developing standards for the transmission of color imagery as part of the facsimile recommendations, including a standard color test chart.

In order to include all of the desired features at reasonable cost, the facsimile test chart must be partitioned into three or possibly four separate charts:

¹ "Color Test Chart for Facsimile", National Communications System Technical Information Bulletin, 91-16, (December, 1991).

the first is a high contrast monochrome chart to allow text and line work to be printed with optimum sharpness and contrast; the second is a continuous tone chart printed on suitable photographic material; the third is a printed color chart with tonal variations rendered as halftones; and the fourth is a photographically reproduced chart with continuous tonal variations. Masters for the first two charts have been completed, and are ready for production. A preliminary prototype of the third chart has been generated and circulated to color experts for comment.

The purpose of this project was to complete and obtain reproducible masters and evaluation prints of the printed color chart, and to define the layout and content of the photographically reproduced chart.

This report is comprised of four sections. Section 1 provides a brief description of the objectives of the study and an outline of the contents of this report. Section 2 discusses the steps taken to produce the final version of the color chart. Section 3 contains the description of the color chart and a guide to its use, and Section 4 is a summary of the work performed.

2. TECHNICAL DISCUSSION

2.1 Color Test Chart Proof Version

At the September 1990 meeting of Study Group VIII a first draft of a high resolution color test chart was presented and discussed (described in TIB 91-16, the report referenced in Section 1). Comments were solicited from national and international experts. Based on the comments received, specific changes were made for the proof version as follows:

1. Gauging color resolution by small primary color dot rosettes in low saturation color patches is more meaningful than the tapered single line and multiple line targets of the last color test chart submitted. The results with the current test targets are quite sensitive to differences in match between the scanning line and the target, but the CMYK resolution target at the top left is retained.

2. The rainbow is replaced by selected color patches. To allow room for a large number of flesh tones, color patches as small as one centimeter square were considered. Large area color patches are used for primary color blocks (CMY and RGB).

3. Type fonts and parallel lines in color to match the color test patches were added.

4. To simulate magazine pages, some text in solid black was added. This tests the very difficult task of performing efficiently for both color and B/W.

5. Two photos replaced the photograph of a balloon: One is a photograph of children and toys in a toy shop, very useful for testing color performance; The other photograph, computer generated, shows a number of overlapping balls, each of a different color, on a black background. A computer program generated selected colors with the number and the size of balls to test bit precision and smoothness. The gradual shading of the color makes them look three-dimensional. Note that on this version of the chart the balls show some contouring. The

contouring results because the printing process can not handle the full gamut of colors generated by the computer program.

A black-and-white copy of the revised color chart is shown in Figure 2.1. This chart was presented in a contribution at the October, 1991 meeting of Study Group VIII.

2.2 Color Test Chart Final Version

At the October 1991 CCITT Study Group VIII meeting the proof version of the color chart was presented, and comments on the chart were requested. Based on the comments received, a new version of the chart was prepared. The actual printed copy of this chart is attached to this report. This full-color chart was printed from 4-color separation negatives by the laminate pre-press proof process. The following changes to the chart were incorporated. 150 line screen images were changed to a 175 line screen. Kanji text was added. The edges of the screened areas slice through the edge screen dots, making them truncated. The number color patches were doubled to provide a smoother transition.

This chart was presented in a contribution at the April, 1992 meeting of Study Group VIII.

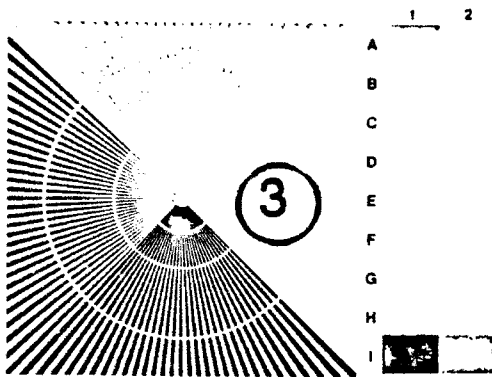
3. TEST CHART DESCRIPTION AND USER INFORMATION

3.1 Color Test Chart Description

The full-color chart was printed from 4-color separation negatives. The laminate pre-press proof process widely used in the color printing industry was used to check the quality of the color separations before setting up the color printing presses. Although these prints should have a greater precision in printing the RGB (2-color) border patterns than would be possible on high quality printing presses, these offset prints are almost indistinguishable from the check plots. The pattern numbers correspond to those found on Figure 3.1. Some of the patterns are the same as the Black/white Test Chart, or modifications thereof to print with color primaries rather than black. Multiple-line and single-line resolution test patterns have been retained, but not in the large variety of pattern types found in the Black/white Test Chart.

1. A border consisting of 4 scales with millimeter markings, one scale per side. On the scales, the 5 and 10 mm lines are extended. The red arrows at the top of the chart are 8 1/2 inches apart. The top border is red (solid magenta and yellow printing). The right border is green (solid yellow and cyan printing). The left border, also marked in inches, is blue (solid cyan and magenta printing). The bottom border consists of three differently colored segments. Its colors are, from left to right, cyan, magenta, and yellow.
2. A black bar at the top of the chart. The bar starts on the left chart edge and ends on the right chart edge. There is a red scale under it. This scale is in inches. It starts with 0 in the middle of the page and has .1" scale markings. Inch markings are slightly extended and are labelled.
3. A Gurley type Pestrecov Star of solid, non-screened, tapered-width lines with three solid-white concentric circles. The pattern is divided into four segments. Clockwise from left, the patterns are cyan, magenta, yellow, and black. The circles, from the outermost to the innermost, have line widths of 50, 100, and 100 pels/inch, respectively. The pattern is printed at full contrast, with the color line width the same as the white spaces between

2



4



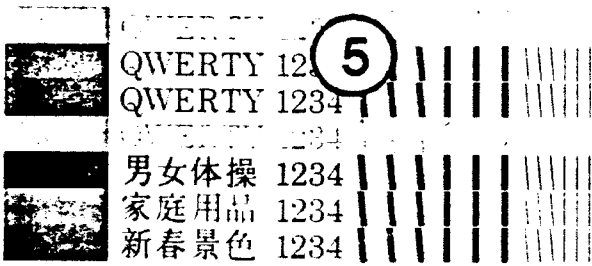
ITU TIMES

CCITT ROLE The CCITT will promote the development of technical facilities and their most efficient operation with a view to improving the efficiency of telecommunication services, increasing their usefulness and making them as far as possible, generally available to the public.

It is the responsibility of the CCITT alone to make the decisions regarding the operational technical (including factors needed to ensure international interworking) and tariff principles of the CCITT-defined *Telegraphic Services*.

NOTE: "Telegraphic Services" includes such services as Facsimile, Teletex, Videotex, etc.

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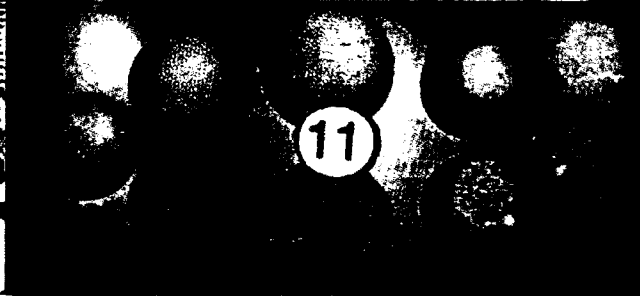
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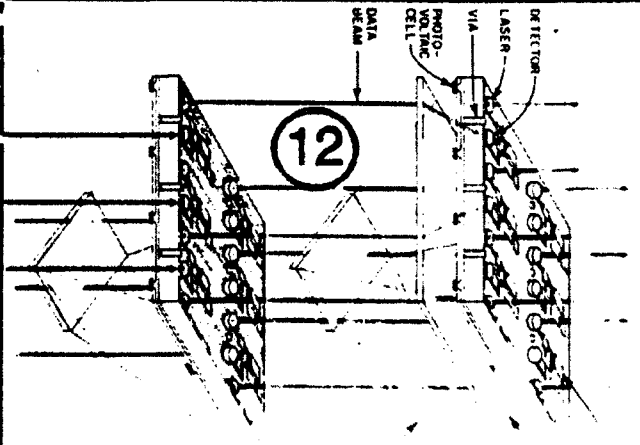
10



11



12



lines.

4. Eighteen colors with eight intensities for each color, for a total of 144 different color patches. The printing color primary magenta is row A (left half). Yellow is row G (left half). Cyan is row M (right half). Of the two-color primaries, red (magenta + yellow) is row D (left half). Green is row J (right half). Blue is row P (right half). Each row between the primaries has a fixed ratio of two printing primaries as the screen dot percentages decrease in steps. Column 8 of each set has 25 percent black added to the printing ink combinations of column 3 to give warmer tones. The screen ruling is 175 lines/inch. Table 1 shows the color combinations of each color patch in percent screen dot density.
5. Twelve light color patches selected from the Macbeth color chart, plus text and isolated line patterns in the same color. The patches, text, and line patterns are organized from left to right, respectively. The line patterns (See Figure 3.2) have line widths of .04, .01, and .005 inches (1.016, .254, and .127 mm). Half of the lines are slanted 1 in 10 to provide random matches between the scanning line sample and the pattern. The text's typeface edges provide a similar function. Kanji characters from the BW01 Test Chart substitute for the "QWERTY" in lines 9 through 12. The screen ruling is 175 lines/inch.
6. Black text that simulates magazine text that might be on the same page as a screened color photo. The text consists of five postscript fonts: headline - Bookman 30p bold, heading - Helvetica 13p, 1st paragraph - New Century Schoolbook 9p, 2nd paragraph - Avante Garde 10p, and the footnote - Helvetica Narrow 6p. The note is repeated in 4 point type and 2 point type.
7. Seven solid unscreened blocks of printing ink colors. These are solid patches of the primary printing ink colors, two-color combinations, plus black. Starting at the left, the colors are cyan, magenta, yellow, red (magenta + yellow), green (yellow + cyan), blue (cyan + magenta), and black.

TABLE 1: COLOR COMBINATIONS (screen dot density in percent)

ROW		COLUMN							8 BLACK	
		1	2	3	4	5	6	7		
A	M	100	75	50	30	20	12	8	50	25
	Y	0	0	0	0	0	0	0	0	
B	M	100	75	50	30	20	12	8	50	25
	Y	33	25	17	10	6	4	3	16	
C	M	100	75	50	30	20	12	8	50	25
	Y	67	50	33	20	13	8	5	33	
D	M	100	75	50	30	20	12	8	50	25
	Y	100	75	50	30	20	12	8	50	
E	M	67	50	33	20	13	8	5	33	25
	Y	100	75	50	30	20	12	8	50	
F	M	33	25	17	10	6	4	3	16	25
	Y	100	75	50	30	20	12	8	50	
G	M/C	0	0	0	0	0	0	0	0	25
	Y	100	75	50	30	20	12	8	50	
H	C	33	25	17	10	6	4	3	16	25
	Y	100	75	50	30	20	12	8	50	
I	C	67	50	33	20	13	8	5	33	25
	Y	100	75	50	30	20	12	8	50	
J	C	100	75	50	30	20	12	8	50	25
	Y	100	75	50	30	20	12	8	50	
K	C	100	75	50	30	20	12	8	50	25
	Y	67	50	33	20	13	8	5	33	
L	C	100	75	50	30	20	12	8	50	25
	Y	33	25	17	10	6	4	3	16	
M	C	100	75	50	30	20	12	8	50	25
	M/Y	0	0	0	0	0	0	0	0	
N	C	100	75	50	30	20	12	8	50	25
	M	33	25	17	10	6	4	3	16	
O	C	100	75	50	30	20	12	8	50	25
	M	67	50	33	20	13	8	5	33	
P	C	100	75	50	30	20	12	8	50	25
	M	100	75	50	30	20	12	8	50	
Q	C	67	50	33	20	13	8	5	33	25
	M	100	75	50	30	20	12	8	50	
R	C	33	25	17	10	6	4	3	16	25
	M	100	75	50	30	20	12	8	50	

NOTE: Column 8 has 25% black added to CMY.

Pattern 5 - Line Portion
5:1 Enlargement
Uses 150 Line Screen

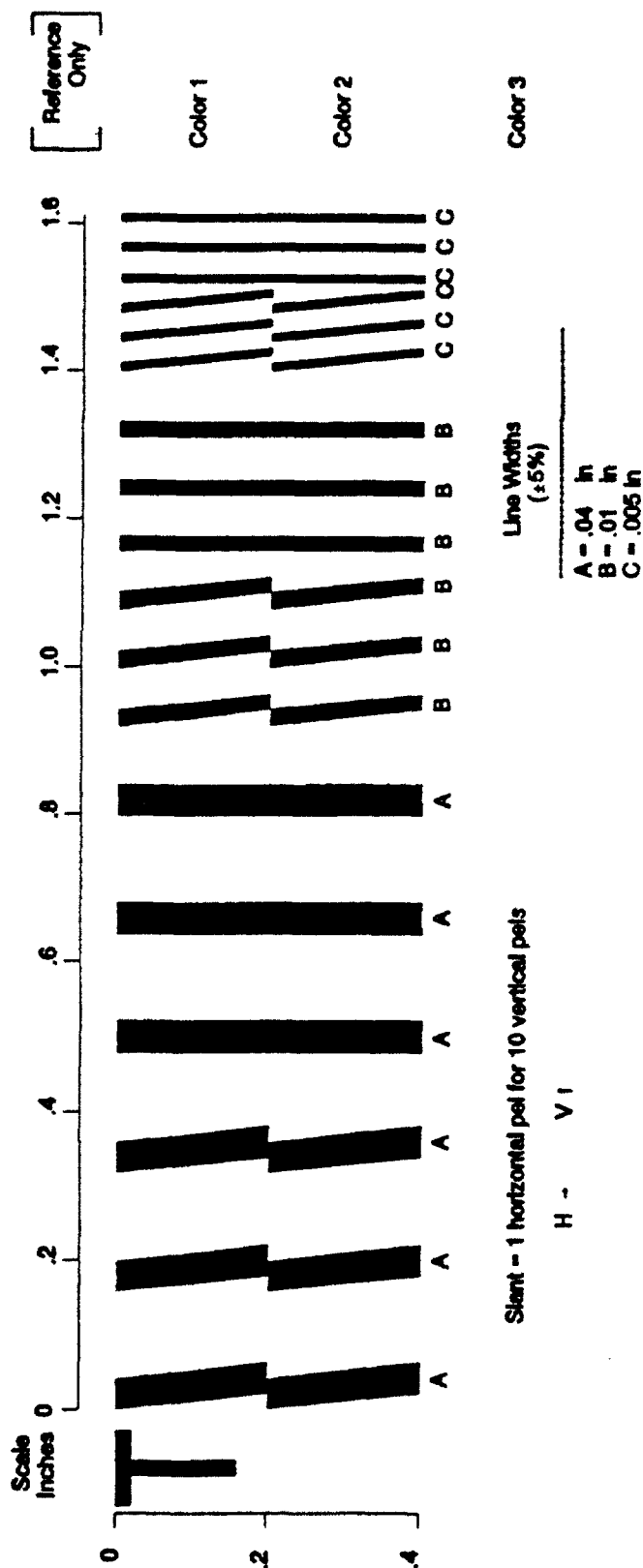


FIGURE 3.2 LINE ENLARGEMENT

8. Eighteen color patches that combine black and each of the printing color primaries. These patches show colors not covered elsewhere in the chart. The first row of six patches uses the cyan primary. The second row uses magenta, and the bottom row uses yellow. These patches were chosen to give good steps to the eye. The left three patches of each row are 100 percent primary overprinted by 60, 40, and 20 percent black dots from left to right, respectively. The next three patches are primary/black combinations of 60/20, 40/20, and 20/20 percent dots. The screen ruling is 175 lines/inch.
9. Three rows of screened gray scales consisting of patches with 90, 75, 50, 25, 10, and 5 percent dots. The first row is 85 line screen. The second row is 175, and the bottom row is 133 line screen.
10. A photograph, called Toys, that has a 175 line screen. It shows higher sharpness for fine detail in the stuffed animals and the faces, and provides a range of textures and patterns. Compare the fuzziness of the stuffed animals to repetitiveness of the blinds to the color combinations present in the man's shirt. The presence of both bright and pastel colors provide widespread variations in luminance, hue, and saturation. In addition, the image is rich in slowly varying color textures mixed with sharp color boundaries. For example, the slowly varying pink of the panther's leg next to the plaid of the girl's skirt.
11. A computer generated simulation of spheres with shadings for a 3-dimensional effect. It shows various-sized differently-colored spheres on a black background. Its 85 line screen represents the low end of color photos in publications like business magazines. Plus, it provides a wide range of color shadings with distinct edges. In general, each sphere is one color, shaded to give a three dimensional appearance. The gradual transition in color of each sphere's shading provides an excellent medium for discerning possible contouring effects. If contouring is present, it will usually manifest itself as a series of concentric circles with slightly different colors. The spheres' edges also provide sharp boundaries against both the black background and other spheres.
12. A graphics image from a magazine cover that has a 150 line screen and exhibits a 3-dimensional effect. It uses pastel colors to denote surfaces and fine black lines to enhance details. It contains a number of repetitive patterns coupled with sharp boundaries between various colors. The white background contains many very small isolated and clumped dots of each primary printing color. Many of these dots are smaller than those used in standard printing processes, providing an additional test target.

13. Following the title, a 5-step CMY gray scale that may be used to check color balance of the printing inks.

3.2 Digitized Color Test Chart

All of the elements of the color test chart now exist in digital form. Except for the photograph, all of the elements were computer-generated. The "toys" image, the "faxballs" image and the computer-generated magazine-cover image have been stored on magnetic tape. The format of these digital images is described in Appendix A. Although all of the images exist in digital form, distribution of these is not recommended until the final version of the chart has been approved for publication. Also at that time, the chart will be scanned to produce a complete chart in one image (at a lower resolution than is available with the individual elements).

3.3 Photographically Reproduced Chart

An objective of this project is to define the layout and content of the photographically reproduced chart. Our approach in defining the four-color printing chart was to design a generic color test chart that could be reproduced in a number of ways. This approach has some obvious advantages: 1) cost savings may be realized if one design can serve for more than one purpose; 2) a given printing process will give the best results for some, if not all, elements of the chart; 3) performance comparisons can be made on common chart elements that have been printed by a different process. For example, scanner performance with respect to a half-tone can be compared with the performance on a continuous tone image easily, if scanning the same image. We plan to use the 4-color printing design to produce the continuous tone version of the chart.

4. SUMMARY

A suite of four test charts have been specified to meet the requirements defined for color facsimile testing. The first two, high contrast and gray-scale test charts, have been approved by Study Group VIII to go forward to the Plenary Assembly as Draft Recommendation T.22. Study Group VIII also recommended that the four-color printing chart be submitted for accelerated procedures at the first meeting of Study Group VIII in 1993.

APPENDIX A

DIGITIZED COLOR CHART

The files are listed on the labels attached to each tape.
There are three CIELAB files,

toys_400lab.img	3242 pixels x 3656 lines
appopt_400lab.img	2644 pixels x 3046 lines
faxballs_lab.img	1024 pixels x 512 lines,

at 8 bits or one byte/pixel with record lengths that are in integer number of 512 bytes and zero pads to fill the record for each line. Each file has header records at the beginning of the file which can be ignored. The number of header records is equal to the minimum number to achieve at least 4096 bytes of header information. This results in the following record lengths and number of header records,

toys_400lab.img	- 3584 bytes/record, 2 header records
appopt_400lab.img	- 3074 bytes/record, 2 header records
faxballs_lab.img	- 1024 bytes/record, 4 header records

There is one RGB file of toys,

toys_400rgb/img	3242 pixels x 3656 lines,
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at 15 bits or two bytes/pixel with the same rules for record lengths and the number of header records resulting in,

toys_400rgb.img	- 6656 bytes/record, 1 header record.
-----------------	---------------------------------------

The RGB file is linear and related to CIE XYZ by the matrix

$$\begin{array}{rcl} \begin{array}{l} R \\ G \\ B \end{array} & = & \begin{array}{ccc|c} 3.2410 & -1.5374 & -0.4986 & X \\ -0.9692 & 1.8760 & 0.0416 & Y \\ 0.0556 & -0.2040 & 1.0570 & Z \end{array} \end{array}$$

which corresponds to SMPTE XA/11 phosphor primaries with chromaticities

Red:	x = 0.640,	y = 0.330
Green:	x = 0.300,	y = 0.600
Blue:	x = 0.150,	y = 0.060,

and a reference white CIE Illuminant D65 with chromaticities, $x = 0.3127$, $y = 0.3290$. To display it on a CRT with those primaries you also have to transfer R, G, and B through independent look-up-tables to correct for the CRT power-law nonlinearity. If that isn't done the image will look dark. For a different set of primaries, you have to use a 3x3 matrix and then the look-up-tables.