COMPUTER-CUSTOMIZED SAS GRAPHICS

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ABSTRACT

A graphics package designed for production of finished output from high-level commands can't be expected to anticipate every feature visualized by a user for a particular graph. Nevertheless, small changes in the standard product would often make a highly acceptable graph out of an unuseable one.

This paper describes computer methods we are using to "customize" SAS graphics produced on Tektronix devices. One method involves interception and modification of graphics instructions generated by SAS/GRAPH procedures. Other methods involve manipulation of the SAS user interface.

Examples of customized graphics methods and results are included, and problems overcome, and not overcome, are discussed. Through computer-customized SAS graphics we are often able to save the time and expense of manual methods or extensive graphics programming.

RESEARCH FOR CONGRESS

At the Library of Congress, subject specialists in the Congressional Research Service (CRS) are using SAS graphics to an increasing extent to help present the results of their research to Congress. The results must be presented with clarity and accuracy, and without any trace of unfairness. Anything that may lead to misunderstanding even on casual inspection is avoided. A graph is examined closely to see whether the point it illustrates comes through clearly enough or whether a misleading impression may be created. Often modifications are needed, with truth in graphics as the goal.

Given the emphasis on clarity and fairness in the presentation of ideas, the research specialists tend to prefer the standard, plain, familiar graphics formats -- bar and pie charts, line and point plots -- but with many types of modifications to more fully emphasize the point being made or to remove any suggestion of bias. Other graphics modifications may be inspired by graphs found in research materials, or by a specialist's personal preference for a particular graphics technique.

ELECTRONIC SCISSORS AND PASTE

The standard charts and plots produced by SAS/GRAPH can be modified in various ways to include custom features made to the order of individual users.

One way to add, delete and move graphics features is to use scissors, paste and white-out, but this approach can become inconvenient for non-artists. Most computer users will want to get by without the scissors and paste, and with as little white-out as possible.

Other ways of modifying graphs use the computer as electronic scissors and paste, and as electronic white-out as well. Use of the computer to modify SAS graphics can be divided into two basic approaches: graphics input (GI) methods, and graphics output (GO) methods. GI methods take advantage of SAS user commands and data sent into the SAS procedures to enhance the graphics produced by the procedures. GO methods begin with the graphics instructions created by the SAS procedures to send to graphics output devices. The graphics device instructions from SAS are selected, modified, and combined with additional device instructions, and sent for display or plotting independently of SAS.

GRAPHICS INPUT MODIFICATIONS

It is probable that every conceivable GI modification has been tried by a SAS user somewhere, but information about modifications is not evenly distributed among users. GI methods may be developed on the spur of the moment to solve specific problems. The solutions may not be the best possible, but merely those that came to hand under the particular circumstances. Standard solutions may be overlooked under time pressure. The results are often unpredictable because SAS programs rearrange the graphics layout in response to changes in commands or data. Different graphics output devices present differing problems and opportunities. Despite the uncertainties in graphics modification techniques, the demand for custom graphs can make them necessary. The following are some examples of GI modifications we have used in the heat of battle, mainly developed through trial and lots of error.

Text Location Chart

Clator and Chapman (1) call attention to a number of GI techniques, and show examples of graphs enhanced through the use of move commands, special data values, and other means. They mention the difficulty of placing text in the correct locations on graphs with the move command.

The number of attempts required to

place lines and text accurately with move and draw commands can be reduced through the use of an overlay showing text locations all over the graphics area (Fig. 1). The numbers in the move and draw commands refer to character positions currently defined for the graphics display area. The move command ".M=(20,10) 20,10" will display on the graph the exact location of the 20th character from the left 10 lines from the bottom, with the currently set number of horizontal and vertical character positions determining the absolute position of a character on the graphics area.

A whole series of these self-locating commands temporarily appended to a graphics program in note statements will show text locations all over the graph. Then the locator commands can be replaced by the actual move and draw commands.

We also make text location overlays on our Tektronix hard copy unit, using a set of self-defining move commands with PROC GCHART. The semi-transparent hard copy with text locations is lined up with a hard-copy version of the graph to show potential text locations.

If the layout of the graph changes, the added text and lines will no longer be in the right locations, so the layout should be final before the extra features are added. If a graph is developed on a Tektronix 4010 series CRT and then sent to a Tektronix 4662 plotter, the added material may be out of position unless the number of text positions is controlled by the GOPTIONS VPOS and HPOS commands.

"Proc Gbox"

The draw and move commands can be used in title and note statements with PROC GSLIDE to create an entire chart. Fig. 2 shows a box chart in which quantities of energy resources are represented by the areas of the boxes. This is a way to display relatively small quantities as areas more effectively than pie charts can.

Line lengths and text positions in the chart are controlled by the VPOS and HPOS commands. Since character positions are taller than they are wide, a multiplier was used to equalize horizontal and vertical line lengths.

A text editor was used to insert the numbers for horizontal and vertical locations in draw command formats for boxes, lines, and right angle line segments. Box size and line length calculations for charts of this kind could be performed automatically by by SAS programs, with SAS put statements creating the PROC GSLIDE commands. The result could be called "PROC CBOX."

Artificial Bar Groups

PROC GCHART ordinarily creates an equal number of bar positions in each group whether or not data exists for all bars in each group. Artificial bar groups with unequal numbers of bars can be constructed by dropping the group subcommand, so that SAS does not try to group the values. Gaps between groups are established by inventing fictional bar variables and setting their values to zero. The fictional bar variables form part of a number series which keeps the bars and the gaps in the correct order on the chart. The format values for the bar variables representing the gaps can be punctuation or other characters suitable for easy application of white-out. Format values must be unique to prevent them from being represented by a single bar. Unique punctuation can be appended to format items appearing more than once. See the example in Fig. 4, with formatting punctuation still visible. Fig. 4 also shows a period as a label removing an unwanted legend variable and the word "legend" as well. Subgroups are identified in the usual way, and the groups are identified in move commands in a footnote statement. This grouping was needed to show actual 1981 figures compared with two sets of forecasts, with not all forecasts present in the second set.

Irregular Line Plots

If unequal time periods are equally spaced in a line plot, the result will be misleading because the slope of the line will be too steep in one period in relation to another. The plot in Fig. 5 has data for the years 1981, 1990 and 1995, giving unequal time periods of nine and five years. With only the three horizontal axis data points on the plot, the unequal time periods would appear to be equal. To correctly space the horizontal axis, intervening time units can be entered into the data observations, with missing vertical axis variables. PROC GPLOT allows space for the extra time units, and draws directly from one actual vertical variable to the next, bypassing the missing values. The extra text on the horizontal axis can then be whited out.

Occasionally different symbols may be required on the same plot line. In Fig. 6 actual and estimated values are plotted on the same line, represented by stars and squares. Symbols can be placed on a plot with move instructions. The symbols in Fig. 6, however, were placed by entering data values for two lines, with the actual data values repeating the estimated values. The stars then overprint and fill in the squares. A solid square from the special font was

used in the footnote.

GRAPHICS OUTPUT MODIFICATIONS

GO methods capture the graphics instructions created by SAS procedures for a particular graphics device, modify the instructions and send them on to the graphics device for display. We have been experimenting with graphics device instructions taken from the SAS FT14F001 graphics output file through the use of the GOPTIONS NOTERMINAL command, and reformatted for input to a text editor. We are using the text editor to study SAS device commands for the Tektronix 4662 plotter, 4010 series graphics CRT, and 4027 color CRT. Our computer system does not currently support graphics image output from the text editor to our 4013 CRT or 4662 plotter. Tektronix 4027 English style commands, however, are easily manipulated and displayed through the text editor.

Tektronix 4027 Modifications

Graphs created by SAS/GRAPH can be modified and redisplayed on the Tektronix 4027 screen. The following procedures were developed by the Systems Programming Office at the Library of Congress to illustrate this process. (See the job stream in Fig. 7.)

The SAS program must contain GOPTIONS DEVICE=TEK4027E NOTERMINAL in order to obtain the English command set for the Tektronix. The output from the SAS program is saved and passed on to another SAS program which reformats the Tektronix commands. Additional JCL to override SAS output (FT14F001) creates a temporary disk data set which is passed on to the next step. This data set has variable length records which must be reformatted before it can be edited by ROSCOE, our text editing facility.

The second SAS program reformats the output into fixed length, 80 character records which can then be edited and modified. One Tektronix command must be inserted before any commands which actually draw commands on the screen are executed. This is the Roll Down (RD02) to scroll the graphics area of the screen two lines to prevent losing the top lines. This command should be inserted after !ERA G. When text is being modified, it may be necessary to change either the x or y coordinate in the !VEC command. Additional text may be added by inserting !VEC, !ATT and !STR commands.

When the editing is completed, the commands can be executed simply by listing them. The commands should be listed without interruption; therefore set the maximum amount for the number of lines that can be written to the terminal without a pause. (In ROSCOE the BREAK command accomplishes this; in TSO use TERM LINES(255).) Also, the lines must be listed without line numbers. The text editor list command causes the 4027 to draw the graph rather than list the commands.

The Tektronix 4027 English style commands are powerful and easy to use. As taken from SAS output, the commands can be altered to make changes in a graph and to store the changes for future use. Text can be erased from the graph by removing the commands that create it, or moved by altering command coordinates. Text, lines and polygons can be added to the graph through Tektronix commands entered into the text editor version of the program. Text in SAS/GRAPH fonts can be combined in the text editor with graphs and charts created by the user in Tektronix polygons and lines. Also, SAS/GRAPH fonts can be displayed on top of SAS/GRAPH or user-created graphics features. The text can be placed inside pie slices, across bars, and on area-fill under lines. Ordinarily, a SAS graphics procedure will cover over text added to a graph because the area fill commands come after the commands that place the extra text. In the text editor, the text commands can be moved to the end of the graphics program, and the text will be written on top of the area fills. See figures 3 and 7 for examples of SAS graphics modified with the text editor or combined with user-written Tektronix commands.

CONCLUSION

Both GI and GO techniques can be effective in extending the usefulness of SAS/GRAPH for meeting the special requirements of users for custom features in graphics. Both techniques can be used in combination. GI methods are easier to use on the spur of the moment, and easier to adapt to different graphics output devices. However, they are more limited in what they can accomplish than GO methods, and less predictable, since they rely on the reaction of SAS programs to changes in commands and data. We are hoping to get more control over GI methods and to extend GO methods to more types of graphics output devices. An exchange of information among users could be useful in propagating the most effective graphics modification methods.

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ROSCOE text editor for displaying SAS graphics.

REFERENCES

(1) Clator, C. Royce and Chapman, Don R. (1982). A Computer Graphics Information System for Upper Management. Proceedings of the Seventh Annual SAS Users Group International Conference, SAS Institute Inc.: Cary, NC.

TEXT LOCATIONS

10,30	20,30	30,30	40,30	50,30	60,30
10,25	20,25	30,25	40,25	50,25	60,25
10,20	20,20	30,20	40,20	50,20	60,20
10,15	20,15	30,15	40,15	50,15	60,15
10,10	20,10	80,10	40,10	50,10	60,10
10,5	20,5	30,5	40,5	50,5	60,5

FIGURE 1.

```
PROC GSLIDE;
TITLE .F=COMPLEX TEXT LOCATIONS;
NOTE .M=(10,5) 10,5 .M=(20,5) 20,5 .M=(30,5) 30,5 .M=(40,5) 40,5 .M=
(50,5) 50,5 .M=(60,5) 60,5;
NOTE .M=(10,10) 10,10 .M=(20,10) 20,10 .M=(30,10) 30,10 .M=
(40,10) 40,10 .M=(50,10) 50,10 .M=(60,10) 60,10;
NOTE .M=(10,15) 10,15 .M=(20,15) 20,15 .M=(30,15) 30,15 .M=
(40,15) 40,15 .M=(50,15) 50,15 .M=(60,15) 60,15;
NOTE .M=(10,20) 10,20 .M=(20,20) 20,20 .M=(30,20) 30,20 .M=
(40,20) 40,20 .M=(50,20) 50,20 .M=(60,20) 60,20;
NOTE .M=(10,30) 10,30 .M=(20,30) 20,30 .M=(30,30) 30,30 .M=
(40,30) 40,30 .M=(50,30) 50,30 .M=(60,30) 60,30;
NOTE .M=(10,25) 10,25 .M=(20,25) 20,25 .M=(30,25) 30,25 .M=
(40,25) 40,25 .M=(50,25) 50,25 .M=(60,25) 60,25;
```

FIGURE 2.

```
GOPTIONS VPOS=35 HPOS=73;
PROC GSLIDE;
TITLE .H=1.5 .F=SIMPLEX Available Energy in Quads .H=
      1.5 (10 .H=(-1+1) .H=.7 15 .M=(+1-1) .H=1.5 BTU);
TITLE2 .H=1.5 .F=SIMPLEX from Recoverable Domestic Energy;
NOTE .D=(10,10,10,11.36,12.19,11.36,12.19,10,10,10) .D=
      (10,10.93,12.19,10.93) .M=
      (10,10) .F=SIMPLEX .H=.7 775;
NOTE .D=(13.38,10,13.38,11.38,15.57,11.38,15.57,10,13.38,10) .D=
      (13.38,11.04,15.57,11.04) .M=(5,5).;
NOTE .D=(17.02,10,17.02,13.57,22.96,13.57,22.96,10,17.02,10) .D=
      (17.02,11.02,22.96,11.02) .M=(5,5) .;
NOTE .D=(24.58,10,24.58,14.85,32.68,14.85,32.68,10,24.58,10) .D=
      (24.58,14.85,24.58,15.35) .D=
      (32.68,14.85,32.68,15.35) .D=
      (24.58,15.85,24.58,16.35) .D=
      (32.68,15.85,32.68,16.35) .D=
      (24.58,16.85,24.58,17.35) .D=
      (32.68,16.85,32.68,17.35) .M=(5,5) .;
NOTE .D=(37.27,10,37.27,29.04,60.49,29.04,60.49,10,37.27,10) .D=
      (37.27,11.7,39.97,11.7,39.97,10) .M=(5,5) .;
FOOTNOTE1 .D=(12.84,19.5,12.84,12.8,11.1,11.4) .D=
      (12.84,12.8,14.48,11.4) .M=(5,21) WITH ENHANCED .M=
      (5,20) RECOVERY .M=(9,8) GAS .M=(8,7) 1,030;
FOOTNOTE2 .M=(10.5,6) PETROLEUM .M=(13,5) 1,100 .D=
      (14.48,10,14.48,7) .H=
      .7 .F=SIMPLEX .M=(13.5,10) 800;
FOOTNOTE3 .M=(17.5,10) 1,200 .M=(16,8) OIL SHALE .M=
      (18.5,7) 5,800 .D=(20,22,20,13.8) .M=
      (17,24) 10 TO 25 .M=(17,23) GAL/TON;
FOOTNOTE4 .M=(24.8,15.85) IN SITU? .M=(25.6,12) 12,000 .M=
      (26.5,8) COAL .M=(25,7) 12,000+;
FOOTNOTE5 .M=(38,20) WITH BREEDER REACTORS .M=
      (37,8) 1,800 .M=(37,7) LIGHT .M=(37,6) WATER .M=
      (36,5) REACTORS .M=(47,8) URANIUM .M=
      (47,7) 130,000;
```

Available Energy in Quads (10¹⁶ BTU) from Recoverable Domestic Energy
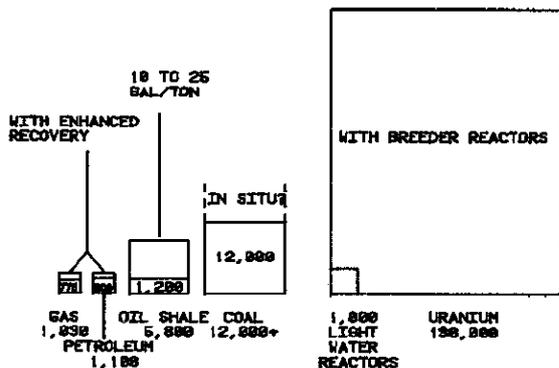
FIGURE 3.

```
IWOR 33
IGRA 1,33
IVEC 320,231
ICOL C1
IPIE 120 0 360
ICOL C6 150 0 360
IPIE 100 0 360
ICOL C2
IPIE 80 0 360
ICOL C4
IPIE 60 0 360
ICOL C5
IPIE 40 0 360
ICOL C3
IPIE 20 0 360
```

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FIGURE 4.

```
GOPTIONS VPOS=35 HPOS=73;
DATA; INPUT FORECAST ETYPE  QUADS YEAR;
IF ETYPE=1 THEN SAVEQUAD=QUADS;
RETAIN SAVEQUAD;
IF ETYPE=2 AND QUADS NE 0 THEN QUADS=QUADS-SAVEQUAD;
LABEL ETYPE='.';
CARDS;
1  1  7  1981
1  2  74 1981
2  1  0  0000
2  2  0  0000
9      1 9.6 1990
9      2 89.1 1990
7      1 9.6 1990
7      2 89.8 1990
6      1 11.3 1990
6      2 88.9 1990
5      1 9.3 1990
5      2 86.5 1990
8      1 10.1 1990
8      2 0 1990
11     1 9.9 1990
11     2 0 1990
4      1 11.1 1990
4    2 90.5 1990
10     1 10.9 1990
10     2 0 1990
3      1 9.7 1990
3      2 86.1 1990
12 1 0 0000
12 2 0 0000
17     1 11 1995
17       2 95.3 1995
16     1 12.8 1995
16     2 96.5 1995
15     1 10.9 1995
15     2 93.9 1995
18       1 11.8 1995
18       2 0 1995
14     1 15.4 1995
14     2 100 1995
13     1 10.6 1995
13     2 93.4 1995
;
PROC GCHART;
TITLE1  .F=COMPLEX FORECASTS OF ENERGY AND ELECTRIC .F=
COMPLEX CONSUMPTION 1990 AND 1995;
VBAR FORECAST/SUBGROUP=ETYPE SUMVAR=QUADS DISCRETE;
FORMAT ETYPE ETYPEF.;
FORMAT FORECAST FOREFMT.;
PATTERN1 V=X1 C=RED;
PATTERN2 V=R1 C=BLUE;
FOOTNOTE1 .M=(24,28) 1990 .M=(53,28) 1995;
```

FORECASTS OF ENERGY AND ELECTRIC CONSUMPTION 1990 AND 1995
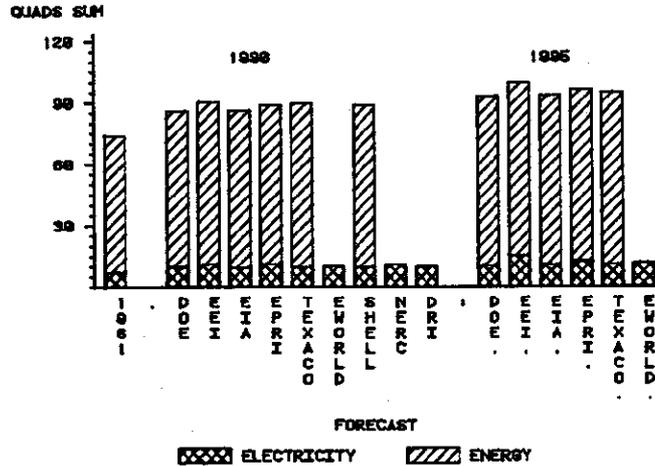
VALUE FOREFMT 1=1981 2='.' 3=DOE 4=EEI 5=EIA 6=EPRI 7=TEXACO 8=EWORLD
9=SHELL 10=NERC 11=DRI 12=':' 13='DOE.' 14='EEI.' 15='EIA.' 16='EPRI.'
17='TEXACO.' 18='EWORLD.';

SUPPLY AND DEMAND FOR ELECTRICITY 1981-1995

FIGURE 5.


```
GOPTIONS VPOS=35 HPOS=73;
DATA; INPUT YEAR $ L1 L2 L3 L4 L5 L6;
LABEL L1=1000 MEGAWATTS;
CARDS;
1981 418 418 418 556 556 556
1982 . . . . . .
1983 . . . . . .
1984 . . . . . .
1985 . . . . . .
1986 . . . . . .
1987 . . . . . .
1988 . . . . . .
1989 . . . . . .
1990 487 539 592 682 717 751
1991 . . . . . .
1992 . . . . . .
1993 . . . . . .
1994 . . . . . .
1995 539 630 729 727 790 853
;.
PROC GPLOT;
TITLE1  .F=COMPLEX SUPPLY AND DEMAND FOR ELECTRICITY 1981-1995;
PLOT L1*YEAR L2*YEAR L3*YEAR L4*YEAR L5*YEAR L6*YEAR
/OVERLAY VAXIS=400 TO 900 BY 100;
SYMBOL1 I=JOIN L=1 C=BLACK;
SYMBOL2 I=JOIN L=3 C=BLACK;
SYMBOL3 I=JOIN L=6 C=BLACK;
SYMBOL4 I=JOIN L=1 C=RED;
SYMBOL5 I=JOIN L=3 C=RED;
SYMBOL6 I=JOIN L=6 C=RED;
FOOTNOTE1 .M=(7,9) DEMAND .M=(7,17) SUPPLY .M=(53,26) HIGH .M=
(53,23.5) MEDIUM .M=(53,21) LOW .M=(50,18) HIGH .M=
(50,15) MEDIUM .M=(50,11) LOW;
```
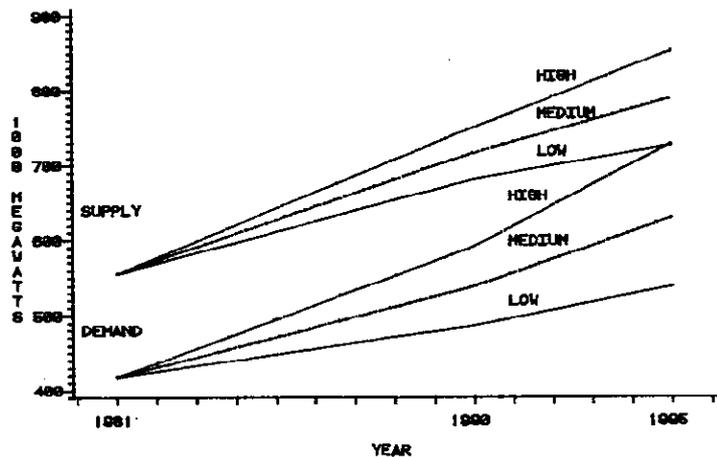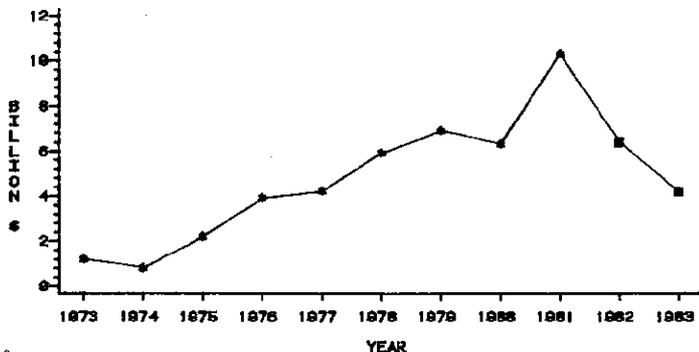
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FIGURE 6.   FEDERAL ENERGY EXPENDITURES SINCE 1973

```
GOPTIONS VPOS=35 HPOS=73;
DATA; INPUT YEAR $ BILLIONS EST;
LABEL BILLIONS=BILLION $;
CARDS;
1973    1.2    .
1974    0.8    .
1975    2.2    .
1976    3.9    .
1977    4.2    .
1978    5.9    .
1979    6.9    .
1980    6.3    .
1981   10.3    .
1982    6.4   6.4
1983    4.2   4.2
;
PROC GPLOT;
PLOT BILLIONS*YEAR EST*YEAR / OVERLAY VAXIS=0 TO 12 BY 2;
SYMBOL1 C=YELLOW V=STAR L=1 I=JOIN;
SYMBOL2 C=YELLOW V=SQUARE;
TITLE .H=2 .F=SIMPLEX FEDERAL ENERGY EXPENDITURES .H=
   2 SINCE 1973;
FOOTNOTE1 .H=1.5 .J=LEFT .C=YELLOW .F=SIMPLEX      * ACTUAL;   * ACTUAL
FOOTNOTE2 .H=1.5 .J=LEFT .C=YELLOW .F=SPECIAL      K .F=       ■ ESTIMATED
   SIMPLEX ESTIMATED;
```


FIGURE 7.

```
//  JOB CARD
//SAS    EXEC SAS,REGION=1024K
//SASLIB DD DSN=SPO.FORMATS,DISP=SHR
//SASG DD DSN=SPO.SASG.TEST,DISP=SHR
//FT14F001 DD DSN=SPO.SAS.GRAFTEST,UNIT=SYSDA,VOL=SER=RXX100,
//      DISP=(,PASS),SPACE=(TRK,(20,20),RLSE)
GOPTIONS DEVICE=TEK4027E NOTERMINAL;
GOPTIONS COLORS=(CYAN,RED,GREEN,BLUE,YELLOW,MAGENTA,WHITE);
PROC GCHART DATA=SASG.CIP;
PIE LTYPE / ASCENDING DISCRETE FILL=S;
FORMAT LTYPE TYPEL.;
TITLE .F=DUPLEX .C=CYAN .H=2 CIP SURVEY;
FOOTNOTE .C=CYAN .F=DUPLEX .H=2 RESPONDENTS; RUN;
//SAS2 EXEC SAS,REGION=1024K
//GRAPHS DD DSN=SPO.SAS.GRAFTEST,DISP=(OLD,KEEP)
DATA _NULL_;
        INFILE GRAPHS;
        FILE PRINT NOTITLES;
        INPUT CHAR $1. @@;
        CC+1;
        IF CHAR='/' THEN INSTR=-INSTR;
        IF CHAR='!'  AND INSTR=-1 THEN DO;
           PUT;
           CC=0;
           END;
        PUT CHAR $1. @;
        IF CHAR=',' AND CC GT 70 THEN DO;
           PUT '▲';
           CC=0;
           END;
        RETAIN CC 0 INSTR -1;
```


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