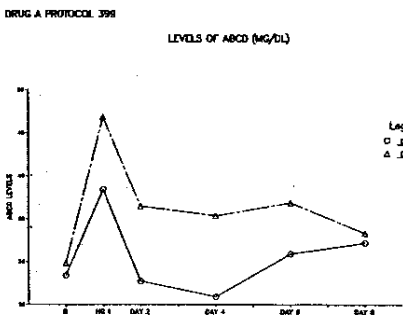


Dorothy Hu Huang
Hoechst-Roussel Pharmaceuticals Inc.

I. INTRODUCTION AND HISTORY OF DEVELOPMENT

GRAPHIX is a user friendly graph generating program written in the SAS® macro language. It allows users to produce high quality graphs without knowledge of CA-TELLAGRAF®, SAS®, or the SAS® macro language. It has been developed at Hoechst-Roussel Pharmaceuticals Inc. to minimize the effort spent in producing standardized graphs. Prior to the introduction of GRAPHIX, many graphs were custom coded in the cumbersome CA-TELLAGRAF® command language, and data points were often entered by hand. With GRAPHIX, the coding of CA-TELLAGRAF® commands is eliminated and data points are directly obtained from SAS dataset.

Graph generation has changed greatly at HRPI over the years. We have improved from coding CA-TELLAGRAF® for each graph and entering data points manually to writing a SASTAG program (a technique, developed at HRPI, of using SAS® to generate CA-TELLAGRAF® commands and input data points), and to using GRAPHIX. Presently, graphs can be generated by a CLIST, which drives DMS panels that collect information from end users, and which then makes subsequent macro call to GRAPHIX.



CA-TELLAGRAF® code

```

GENERATE A LABELED PLOT.
X AXIS LABEL HEIGHT= 10.
Y AXIS LABEL HEIGHT= 10.
X AXIS ORIGIN=1.2 LENGTH=8,MIN=1,MAX=9,STEP=1.
X AXIS SHIFT IS ENABLED.
CROSS IS DISABLED.
Y AXIS ORIGIN=1.1 LENGTH=4.8,MIN=25,MAX=50,STEP=5.
Y AXIS LABEL = "ABCD LEVELS".
X AXIS DIVISION LABELS
"0" "HR 1" "DAY 2" " " "DAY 4" " " "DAY 6" " " "DAY 8".

INPUT DATA.
" DRUG A 1000 U " 1,28.4 2,38.4 3,27.7 5,25.9 7,30.9 9,32.2
" DRUG B 2000 U " 1,29.8 2,46.8 3,36.4 5,35.3 7,36.8 9,33.3

END OF DATA.
CURVE 1 COLOR=BLACK,SYMBOL COUNT=1,SYMBOL TYPE 17,TEXTURE=1.
CURVE 2 COLOR=RED,SYMBOL COUNT=1,SYMBOL TYPE 2,TEXTURE=4.
LEGEND ORIGIN X=80,Y=50,PAGEX.
LEGEND EXISTENCE IS ON.
LEGEND HEIGHT= 10.
EVERY CURVE THICKNESS=3.
EVERY MESSAGE HEIGHT=0.15, PAGE X.
MESSAGE 1 IS
"DRUG A PROTOCOL 399"
CONNECT LT Y=87,X=6,JUST LEFT.
MESSAGE 2 IS
"LEVELS OF ABCD (MG/DL)"
CONNECT CT Y=80,X=50,PAGEX.
GO.
    
```

SASTAG

```

PROC MEANS;
BY PROT TGRP VISIT;
VAR ATZMUD;
OUTPUT OUT=MSET MEAN=MX;

DATA _NULL_ ;SET MSET END=DONE; BY PROT TGRP VISIT;
RETAIN COUNTA COUNTB;
FILE TAGOUT;
IF FIRST PROT THEN DO;
PUT "GENERATE A LABELED PLOT."//
"X AXIS LABEL HEIGHT= 10."//
"Y AXIS LABEL HEIGHT= 10."//
"X AXIS ORIGIN=1.2 LENGTH=8,MIN=1,MAX=9,STEP=1."//
"X AXIS SHIFT IS ENABLED."//CROSS IS ENABLED//
"Y AXIS ORIGIN=1.1 LENGTH=4.8,MIN=25,MAX=50,STEP=5."//
"Y AXIS LABEL = "ABCD LEVELS"."//
"X AXIS DIVISION LABELS "0" "HR 1" "DAY 2" "DAY 4" "DAY 6" "DAY 8"."//
END;
***** INPUT *****
IF FIRST TGRP AND TGRP=1 THEN DO;

COUNTA=0;
PUT "INPUT DATA."//; DATACT=0;
END;
IF FIRST TGRP THEN DO;
COUNTA+1;
PUT TGRP ATGRP. " " @;
END;
PUT VISIT 2.0 " " MX 4.1 " " @;
DATACT+1;
IF TGRP=1 AND DATACT=6 AND LAST.PROT THEN DO;
PUT / @; DATACT=0;
END;
IF LAST TGRP AND TGRP=1 THEN PUT //; "END OF DATA."//;
IF LAST TGRP AND TGRP=2 THEN PUT //; "END OF DATA."//;
"CURVE 1 COLOR=BLACK,SYMBOL COUNT=1,SYMBOL TYPE 17,TEXTURE=1."//
"CURVE 2 COLOR=RED,SYMBOL COUNT=1,SYMBOL TYPE 2,TEXTURE=4."//
"LEGEND ORIGIN X=80,Y=50,PAGEX."//
"LEGEND EXISTENCE IS ON."//
"LEGEND HEIGHT= 10."//
"EVERY CURVE THICKNESS=3."//
"EVERY MESSAGE HEIGHT=0.15, PAGE X."//
"MESSAGE 1 IS"//
"DRUG A PROTOCOL 399"//
"CONNECT LT Y=87,X=6,JUST LEFT."//
"GO."//
RETURN;
***** FILE PRINTOUT *****
DATA _NULL_ ; INFILE TAGOUT; FILE PRINT; INPUT; PUT _INFILE_ ;
    
```

GRAPHIX

```

%GRAPHIX(X=VISIT Y=ATZMUD CURVAR=TGRP
PAGE=PROT INVEST XMIN=1 XMAX=8 YSTEP=1 YMIN=25 YMAX=50 YSTEP=5.
YLABEL=ABCD LEVELS CURVMT=TGRP.
ULSTZ=DRUG A PROTOCOL 399
TITLE=LEVELS OF ABCD (mg/dl).
XDLFW=DX.)
    
```

II. CAPABILITIES

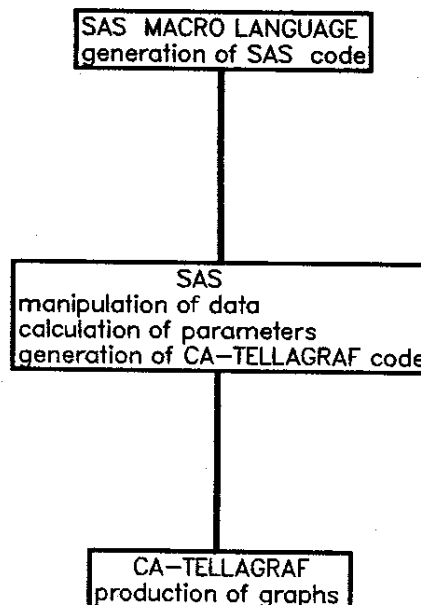
GRAPHIX has been developed in response to user needs. Its capabilities are tailored to the graphical requests received by the Medical Systems Department. Some of the specific ones include:

- Accepting data with different organizations.
- Generating messages to describe the graph.
- Presenting data in different graphical formats, eg, line, bar, scatter, and spaghetti plots.
- Calculating and displaying frequency counts associated with data values.
- Plotting mean and individual graphs.
- Drawing standard errors on mean graphs.
- Entering additional CA-TELLAGRAF® commands to modify the graph.

III. METHODOLOGY

GRAPHIX utilizes the SAS® macro language to generate SAS® code, which in turn generates CA-TELLAGRAF® commands. The input data are required to be stored in a SAS® dataset. The dataset is manipulated by GRAPHIX in the desired structure. The necessary parameters, ie, mean, standard error, and frequency counts, are calculated subsequently. Finally, utilizing the PUT statement in the DATA_NULL_step, the CA-TELLAGRAF® code is generated and submitted. The two-step processing, namely SAS® and CA-TELLAGRAF®, is transparent to the user. The system programmer at HRPI has written a "SASTAG" JCL procedure to handle the above processing.

METHODOLOGY OF THE GRAPHIX SYSTEM



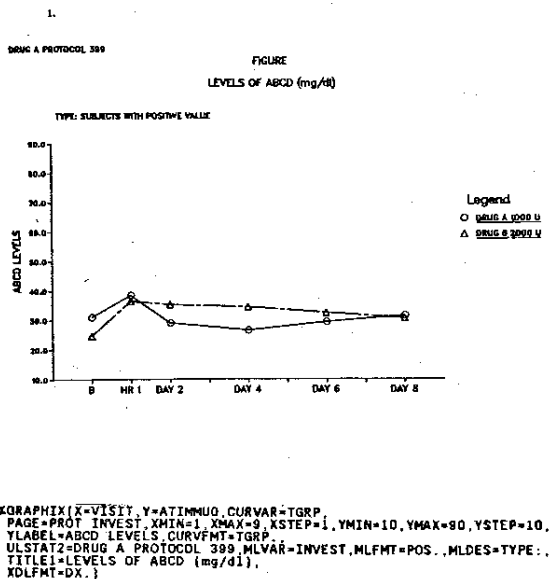
IV. MACRO VARIABLES

The macro variables are utilized to describe the data, the statistics, and graphical content and form to the GRAPHIX system. Data are described by the macro variables DATASET and ORGANIZATION. These inform the program of the location of the data and how the data are organized. The statistics are represented by macro variables TYPE, FREQ, SE, and REF(erence). TYPE variable can be set to equal MEAN, indicating that PROC MEANS is to be performed on the input data and a mean graph is to be generated, or can be set to equal ALL, indicating that individual graphs are to be done. When FREQ variable is set to YES, frequency counts associated with the data values are printed on the bottom of the graph. Standard error lines can be drawn by setting SE equal to YES. The user also has the option of shifting them if the lines interfere with each other. REF variable tells the location of a reference line; it can be a variable or a constant. The remaining macro variables are used to describe the content and form of the graph. CHART

indicates the graphical form: line, bar, scatter, or spaghetti. XMIN, XMAX, YMIN, YMAX input the x-axis and y-axis minimal and maximal values. CURVAR informs the program which by-variable is represented by a curve, eg; treatment group, investigator. PAGE can be a string of variables that graphs are paged by. Many other, including XLABEL, YLABEL, TITLE1, and LEGEND are used to annotate the graphs. A special variable, TAGCOM, was implemented for those users who have knowledge of CA-TELLAGRAF® commands and desire to modify the graphs. For instance, the user may want to change the type of curve symbol used or the window size(TAGCOM="CURVE 1 SYMBOL TYPE=3). It may seem that there are a vast number of macro variables to be filled, however, the majority of them have default values.

V. EXAMPLES

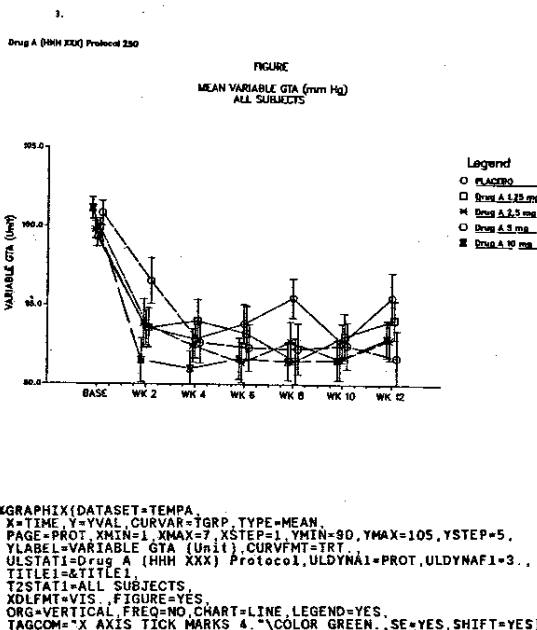
The ease of using GRAPHIX and the high quality of the graphs generated can best be demonstrated by some examples.



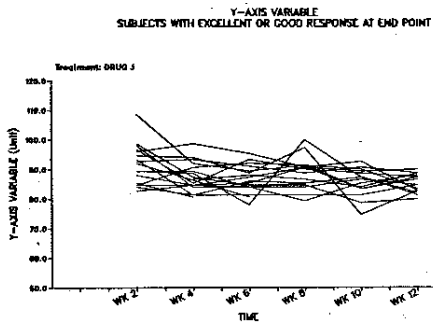
```

XGRAPHIX(
X=VISIT, Y=ATIMMUO, CURVAR=TGRP, TYPE=MEAN,
PAGE=PROT INVEST, XMIN=1, XMAX=9, XSTEP=1, YMIN=10, YMAX=90, YSTEP=10,
YLABEL=ABCD LEVELS, CURVFM=TGRP,
ULSTAT2=DRUG A PROTOCOL 389,
TITLE1=LEVELS OF ABCD (mg/dl),
T2DYNAL=INVEST, T2DYNALF=POS,
FOOT="This is the first line.",
XDLFMT=DX, FIGURE=YES, SE=YES, SHIFT=NO,
ORG=VERTICAL, FREQ=YES, CHART=LINE, LEGEND=YES, ORIENT=VERTICAL)

```



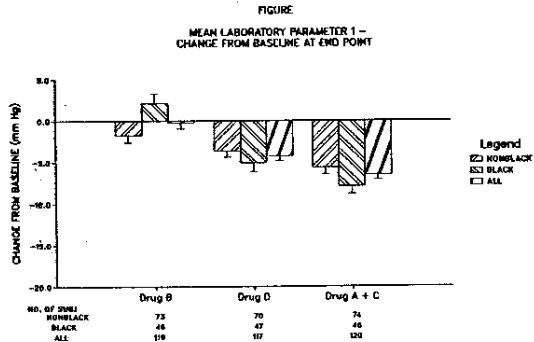
4. Drug A (XXX 000) Protocol 253



Wk is an example of spaghetti plot.
It's one of the four types of plots generated.

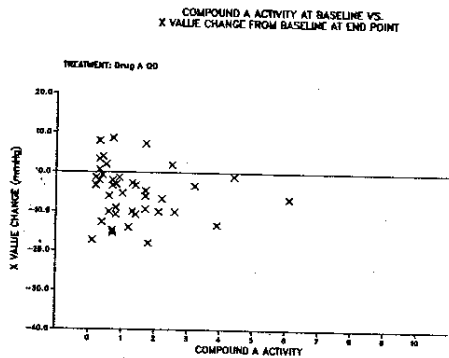
```
XGRAPHIX(DATASET=BPQ,
X=VISIT Y=YV CURVAR=SUBJECT,TYPE=ALL,
PAGE=PROT TGRP FF,
XMIN=1,XMAX=13,XSTEP=1,YMIN=50,YMAX=120,YSTEP=10,
ALABEL=TIME,YLABEL=Y-AXIS VARIABLE (Unit),CURVFMT=3,
ULSTAT1=Drug A (XXX 000) Protocol,ULDYNA1=PROT,ULDYNAF1=3,
TITLE1=Y-AXIS VARIABLE,
T2STAT1=SUBJECTS WITH, T2DYNA1=FF, T2DYNA1F=FF, T2STAT2=AT END POINT,
MLDES=Treatment:,MLVAR=TGRP,MLFMT=TRTX,
FOOT="This is an example of spaghetti plot,"
" it's one of the four types of plots generated.",
XDLFMT=VIS,
ORG=VERTICAL,CHART=SPAGHETTI,LEGEND=NO,FREQ=NO,FIGURE=NO)
```

6. Drug B (HHH 999) Protocol 351



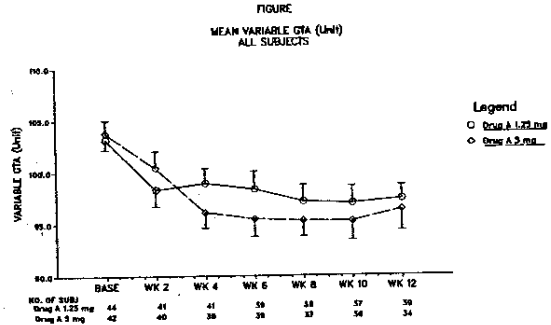
```
XGRAPHIX(DATASET=LAST,
X=TGRP Y=GLMVAR,CURVAR=TGRP,TYPE=MEAN,SE=YES,
PAGE=PROT VAR RACE,XMIN=1,XMAX=3,XSTEP=1,YMIN=-15,YMAX=5,YSTEP=5,
KLABEL=,
YLABEL=CHANGE FROM BASELINE (mm Hg),CURVFMT=FAKE,
ULSTAT1=Drug XYZ (JJJ 100) Protocol,
ULDYNA1=PROT,ULDYNAF1=3,
ULSTAT2=,ULDYNA2=,ULDYNAF2=,
TITLE1=,
T2STAT1=MEAN, T2STAT2=,
T2DYNA1=VAR, T2DYNA1F=BPTYP, T2DYNA2=,
T2DYNA2F=, T3STAT1=CHANGE FROM BASELINE AT END POINT,
T3DYNA1=RACE, T3DYNA1F=STATRACE, T3STAT2=SUBJECTS,
FOOT=,
MLDES=, MLVAR=, MLFMT=,
XDLFMT=FAKE, FIGURE=YES,
ORG=VERTICAL, FREQ=YES, FRETEXT=, CHART=BAR, LEGEND=NO, ROOT=0,
TAGCOM=BAR WIDTH 60.];
```

5. Drug A (XXX 000) Protocol 253



```
XGRAPHIX(DATASET=ALL,
X=COMPX, Y=CHGXX2, CURVAR=SUBJECT, TYPE=ALL,
PAGE=PROT TGRP,
XMIN=0, XMAX=10, XSTEP=1, YMIN=-40, YMAX=20, YSTEP=10,
KLABEL=COMPOUND A ACTIVITY, YLABEL=X VALUE CHANGE (mmHg),
CURVFMT=3,
ULSTAT1=Drug A (XXX 000) Protocol 253,
TITLE1=COMPOUND A ACTIVITY AT BASELINE VS,
T2STAT1=X VALUE CHANGE FROM BASELINE AT END POINT,
MLDES=TREATMENT:,MLVAR=TGRP,MLFMT=TRTX,
ORG=VERTICAL,CHART=SCATTER,LEGEND=NO,FREQ=NO,FIGURE=NO,
RFF=JB.TAGCOM=EVERY CURVE SYMBOL TYPE=4,EVERY CURVE COLOR BLACK.)
```

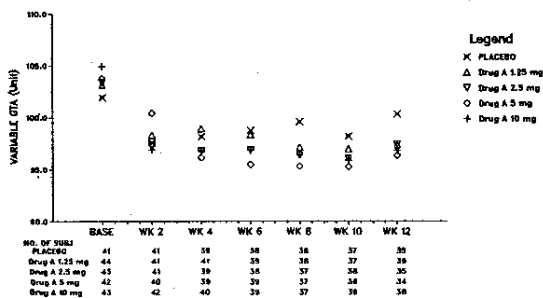
7. Drug A (HHH XXX) Protocol 250



```
XGRAPHIX(DATASET=TEMPA,
X=TIME Y=YVAL, CURVAR=TGRP, TYPE=MEAN,
PAGE=PROT, XMIN=1, XMAX=7, XSTEP=1, YMIN=80, YMAX=110, YSTEP=5,
YLABEL=VARIABLE GTA (Unit), CURVFMT=TRT,
ULSTAT1=Drug A (HHH XXX) Protocol,ULDYNA1=PROT,ULDYNAF1=3,
TITLE1=&TITLE1,
T2STAT1=ALL SUBJECTS,
XDLFMT=VIS, FIGURE=YES,
ORG=VERTICAL, FREQ=YES, CHART=LINE, LEGEND=YES,
TAGCOM="X AXIS TICK MARKS 4.", SE=YES]
```

Drug A (MHH XXX) Protocol 250

FIGURE
MEAN VARIABLE GTA (U/H)
ALL SUBJECTS



```
XGRAPHX(DATASET=TEMPA,
X=TIME, Y=YVAL, CURVAR=IGRP, TYPE=MEAN,
PAGE=PROT, XMIN=1, XMAX=7, XSTEP=1, YMIN=90, YMAX=110, YSTEP=5,
YLABEL=VARIABLE GTA (U/H), CURVMT=TRT,
ULSTAT1=Drug A (MHH XXX) Protocol, ULDYN1=PROT, ULDYN1F1=3.,
TITLE1=&TITLE1,
T2STAT1=ALL SUBJECTS,
XDIFMT=VIS, FIGURE=YES,
ORG=VERTICAL, FREQ=YES, CHART=SCATTER, LEGEND=YES,
TAGCOM="X AXIS TICK MARKS 4.")
```

This technique offers the following advantages:

1. Saves end users from having to learn another language.
2. Makes use of the features from both languages - SAS® to do data processing and parameter calculation, CA-TELLAGRAF® to generate graphs.
3. Saves time and gives accurate, reliable results.

ACKNOWLEDGEMENT

I would like to thank my supervisor, Bernard Costa, and my co-worker, Christian Forster, for all the help and encouragement extended to me which made this project possible.

VI. COMPARISON BETWEEN CA-TELLAGRAF® AND SAS/GRAPH®

CA-TELLAGRAF®

1. Longer history, widely used, proven product.
2. Annotation is simpler.
3. Code is English-like.
4. Multiple charts per page capability.
5. Manual is easier to read.
6. IVISS.

SAS/GRAPH®

1. Interfaces with other SAS® facilities.
2. Mapping capability.
3. 3-D capability.
4. Template facility.

VII. FUTURE DEVELOPMENT

1. Multiple plots per page.
2. Additional parameter calculation.
3. Positioning messages based on data values.

VIII. GENERALIZATION TO OTHER COMMAND LANGUAGES

As can be seen, the technique that I have used in writing GRAPHIX can be generalized to other command languages.