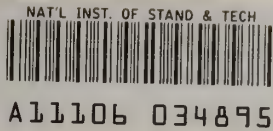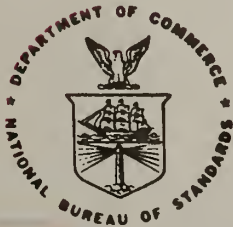NBSIR 83-2779

Release Notes for STAT2 Version 1.31: An Addendum to NBS Special Publication 400-75

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
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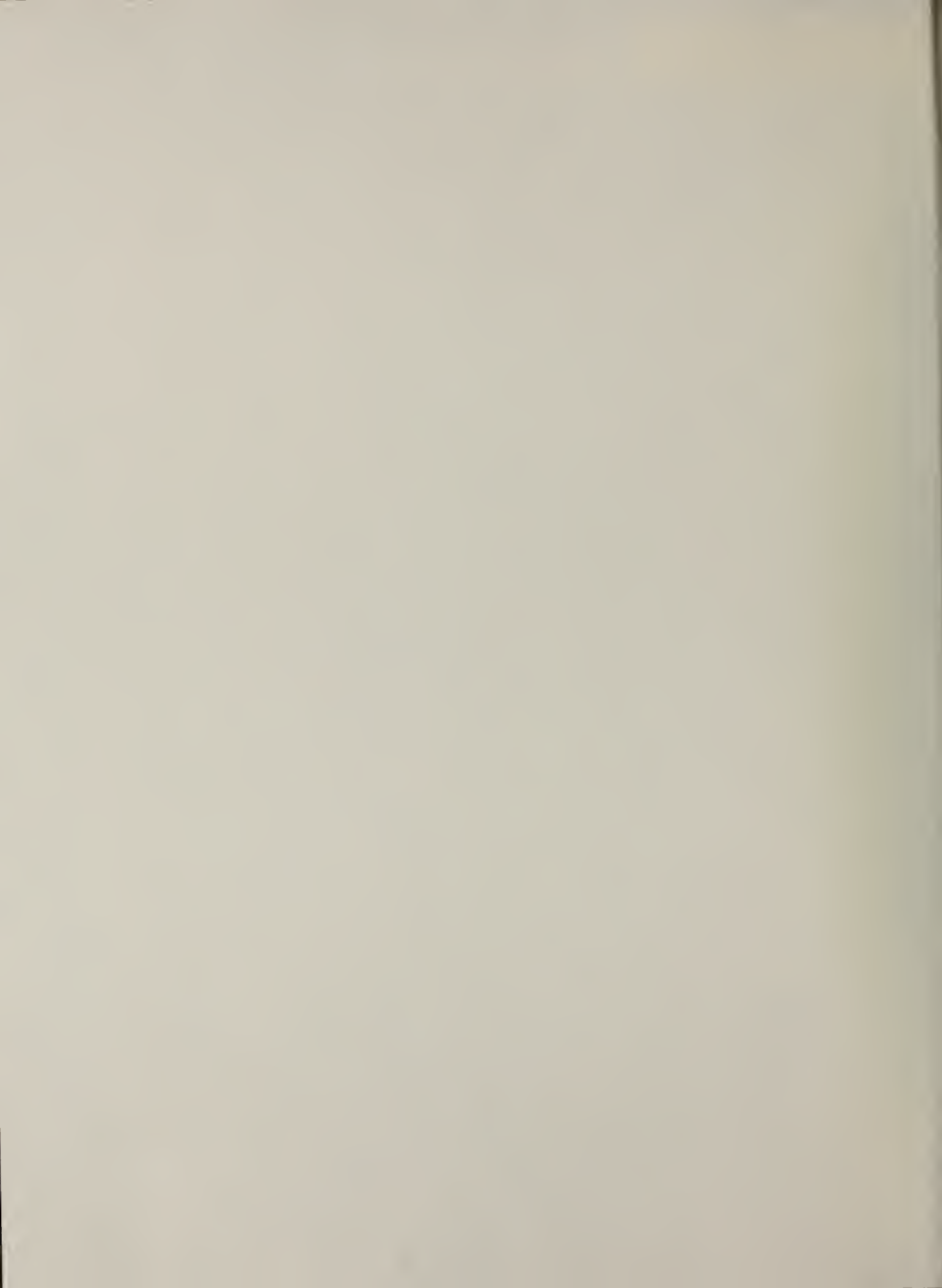NBSIR 83-2779

RELEASE NOTES FOR STAT2 VERSION 1.31: AN ADDENDUM TO NBS SPECIAL PUBLICATION 400-75

R. L. Mattis and R. Zucker

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Disclaimer

Certain commercial equipment, instruments or materials are identified in this report in order to adequately specify the experimental procedure. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the material or equipment identified is necessarily the best available for the purpose.

Release Notes for STAT2 Version 1.31:
An Addendum to NBS Special Publication 400-75

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Abstract

This document describes the changes which have been made in the
STAT2 computer program. The new version contains several new fea-
tures which provide a more powerful data base capability, improved
displays, and greater compatibility with the automatic tester. In
going from the original version 1.01 to version 1.31, the DATA
array has been redefined and new REA command formats have been
added to be compatible with new data acquisition equipment. A new
circular shaded map has been added which gives a more realistic
representation of data variation over a wafer surface. New map and
histogram scaling options allow greater flexibility in specifying
the scale of data displays. A new format for two data base com-
mands allows greater flexibility in selectively listing and corre-
lating data base entries. The capability has been added for elimi-
nating some unwanted printout, and for creating macro command files
within a STAT2 run. Finally, a new method of specifying the direc-
tory containing the Help files makes STAT2 easier to install.
Following the description of the changes is an annotated listing of
new error messages.

Key words: ATE; computer program; contour map; data base; outlier;
process validation wafer; statistical analysis; two-dimensional
map; wafer map.

Warning

The structure of the data base has been changed in version 1.31 of STAT2. Do
not try to use any of the data base commands of version 1.31 on a data base
created under version 1.01 until the data base has been updated as described
in section 6.2.

1. Introduction

This document describes the changes which have been made in the STAT2 computer program since its documentation in NBS Special Publication 400-75, *Semiconductor Measurement Technology:* A FORTRAN Program for Analysis of Data from Microelectronic Test Structures. It is assumed that the reader has this document, and no attempt is made to review STAT2 features or operation. The new version contains several new features which provide a more powerful data base capability, improved displays, and greater compatibility with the automatic tester. This report describes the new features and then gives an alphabetical list of new error and warning messages. Three appendices are included which give the files which are needed to update previously created data bases as explained in section 6.2.

2. New Data Array Definition

In version 1.01 of STAT2 [1], the DATA array was defined such that row 1 was at the bottom of the wafer. The order in which sites were tested and the STEND array relating to a sample DATA array were shown in figure 1 of [1]. In version 1.31, row 1 is at the top of the wafer instead of at the bottom. The order of site testing is left to right in a raster pattern which advances from the top row to the bottom row. If data taken using the "old" site locations convention are input to version 1.31 of STAT2, the topological types for top and bottom and for upper and lower corners will be reversed, and the mapping commands will produce a display which is a mirror image of the data about a horizontal axis.

3. New REA Command Formats

3.1 Format 4

STAT2 format 4 is intended for processing data taken by an Accutest 3000 parametric test system. In normal testing operation, the Accutest writes data values to a binary file having a .LOG extension. The Accutest utility LOGASC converts the data to ASCII in a file having a .LGA extension. A simple example of a .LGA file is shown in figure 1. Data from each chip are preceded by a POS statement which identifies the chip by its column and row numbers. Data values are contained in VAL statements which follow each POS statement. The data values are given in the order in which they were logged which, in turn, is governed by the testing program which took the data. The .LGA file of figure 1, for example, is from a testing program in which two parameters were measured in each of five chips. Note that there are two VAL statements associated with each POS statement. The data representing each of the parameters is distributed throughout the file. The data from the first parameter measured, which is called data set number one, are contained in the first VAL statement for each chip. The data from the second parameter measured, which is called data set number two, are given in the second VAL statement for each chip. When reading data using format 4, the second parameter of the REA command specifies the data set number within the .LGA file which is to be read and analyzed by STAT2. For example, data set number 1 would be read by the command REA,4,1.

```
TPN  UTLMOSFET
STA      1
DAT  02-FEB-83
BTI  08:26:16
ETI
OPE
LOT
DEV
WFT
TSN
DSN      1
WFN      1
DIE      1
POS  1.000000E+00  1.000000E+00    <--- Column and row of first site measured
VAL      1 -8.882344E-01           <--- Value of first parameter at first site
VAL      2  1.403333E-06           <--- Value of second parameter at first site
BIN      0
DSN      2
WFN      1
DIE      2
POS  2.000000E+00  1.000000E+00    <--- Column and row of second site measured
VAL      1 -9.098073E-01           <--- Value of first parameter at second site
VAL      2  1.463333E-06           <--- Value of second parameter at second site
BIN      0
DSN      3
WFN      1
DIE      3
POS  3.000000E+00  1.000000E+00
VAL      1 -9.338425E-01
VAL      2  1.430000E-06
BIN      0
DSN      4
WFN      1
DIE      4
POS  1.000000E+00  2.000000E+00
VAL      1 -9.254654E-01
VAL      2  1.413333E-06
BIN      0                              Note that no data appears at coordinates
DSN      5                              (2,2) which was designated an untested site.
WFN      1
DIE      5
POS  3.000000E+00  2.000000E+00    <--- Column and row of last site measured
VAL      1 -9.159812E-01           <--- Value of first parameter at last site
VAL      2  1.413333E-06           <--- Value of second parameter at last site
BIN      0
EOF
***
```

Figure 1. Annotated example of a .LGA file to be read using format 4.

4

```
1      3    <--- First row of sites starts in column 1 and ends in column 3
1      3    <--- Second row of sites starts in column 1 and ends in column 3
0      0    <--- Signals no more rows of sites
2      2    <--- Site at row 2 column 2 is not tested
0      0    <--- Signals no more untested sites
```

Figure 2. Annotated example of a .SAD file which is
           the companion to the .LGA file of figure 1.

Coordinate information is contained in a file having a .SAD extension. The
.SAD file which goes with the .LGA file of figure 1 is given in figure 2.
The first part of the .SAD file contains the starting and ending columns
measured for all rows which were probed. This part of the file defines the
STEND array and is followed by a pair of zeroes. Following this are the
row-column coordinate locations of all untested sites within the region
defined by the STEND array. The file concludes with a final pair of zeroes.

In order to read data using format 4, (1) use the ASG command to enter the
file specifier of the .LGA file containing the data to be analyzed, (2) issue
the REA command as REA,4,i, where i is the data set number to be read, and
(3) in response to the prompt, enter the file specifier of the .SAD file.
When examining several data sets from the same .LGA file, it is not necessary
to re-issue the ASG command. Furthermore, the file specifier of the .SAD
file need not be re-entered; the user need only enter an asterisk to indicate
that the same .SAD file is to be used.

3.2   Format 5

STAT2 format 5 allows STAT2 to do certain types of analyses on test data
where the test sites are not in a contiguous region but are randomly placed
on a wafer. As with format 4, the data are read from a .LGA file produced on
an Accutest 3000 test system and the second parameter of the REA command
specifies the serial order of the data set within the data from each die. An
example of a .LGA file which can be read using format 5 is given in figure 3.
The accompanying .SAD file differs from that of format 4 in that the first
record contains the number of sites tested, and the subsequent records give
the explicit row-column locations of these sites. The .SAD file which goes
with the .LGA file of figure 3 is shown in figure 4.

```
TPN  UTLMOSFET
STA        1
DAT  03-FEB-83
BTI  09:43:22
ETI
OPE
LOT
DEV
WFT
TSN
DSN        1
WFN        1
DIE        1
POS  3.000000E+00 1.000000E+00   <--- Column and row of first site measured
VAL        1 -8.734293E-01        <--- Value of first parameter at first site
VAL        2  1.382721E-06        <--- Value of second parameter at first site
BIN        0
DSN        2
WFN        1
DIE        2
POS  7.000000E+00 2.000000E+00   <--- Column and row of second site measured
VAL        1 -9.114932E-01        <--- Value of first parameter at second site
VAL        2  1.458231E-06        <--- Value of second parameter at second site
BIN        0
DSN        3
WFN        1
DIE        3
POS  5.000000E+00 6.000000E+00
VAL        1 -9.283744E-01
VAL        2  1.830000E-06
BIN        0
DSN        4
WFN        1
DIE        4
POS  2.000000E+00 4.000000E+00
VAL        1 -9.300284E-01
VAL        2  1.382773E-06
BIN        0
DSN        5
WFN        1
DIE        5
POS  1.000000E+00 5.000000E+00   <--- Column and row of last site measured
VAL        1 -9.201833E-01        <--- Value of first parameter at last site
VAL        2  1.382261E-06        <--- Value of second parameter at last site
BIN        0
EOF
***
```

Figure 3. Annotated example of a .LGA file to be read using format 5.

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```
5                      <--- There were 5 sites measured
1           3          <--- The first site measured was at row 1 column 3
2           7          <--- The second site measured was at row 2 column 7
6           5
4           2
5           1          <--- The last site measured was at row 5 column 1
```

Figure 4. Annotated example of a .SAD file which is the
companion to the .LGA file of figure 3.

Internally, when reading data in format 5, STAT2 stores data values in
DATA(1,1), DATA(1,2), ... , DATA(1,32), DATA(2,1), ... , etc., until all
values (up to 1024 of them) are read in. The STEND array in this case con-
tains no information about the site locations but only defines the elements
of the DATA array which contain actual data. The actual site locations are
contained in two arrays IXCOL and IYROW, each dimensioned (32,32). The
LSITES array still contains a record of excluded sites. The topological type
has no meaning in this situation, and the TYPE array elements of all sites
are set equal to 10. The row or column coordinate of all sites must not
exceed 32.

In order to read data using format 5, (1) use the ASG command to enter the
file specifier of the .LGA file containing the data to be analyzed, (2) issue
the REA command as REA,5,i, where i is the data set number to be read, and
(3) in response to the prompt, enter the file specifier of the .SAD file.
When examining several data sets from the same .LGA file, it is not necessary
to re-issue the ASG command. Furthermore, the file specifier of the .SAD
file need not be re-entered; the user need only enter an asterisk to indicate
that the same .SAD file is to be used.

The user must be careful when designing a sampling plan to write a data base
using format 5 data because the subscripts of the DATA array do not give the
actual site locations. Alternatively, sampling plan 4, which includes all
sites measured in the sampling plan, is still valid for format 5 data. Addi-
tionally, because the sites are not contiguous when reading in format 5, the
following commands are not allowed and produce an error message: AIP, AXP,
FPL, FQD, MP1, MP2, MP3, MP4, PLT, SPL, SQD, and XPP.

4. The Circular Shaded Map

A new command has been added to draw a shaded or gray-tone map in which the
shades extend to a circular boundary. Extrapolation algorithms are used to
extend the map beyond the region containing the actual test sites to the
boundary. A sample circular shaded map is given in figure 5 and the accom-
panying key in figure 6. As with the MP2 map (which is still available), the
new map is written specifically for the VAX computer and Printronix P300 line
printer. The format of the new command is

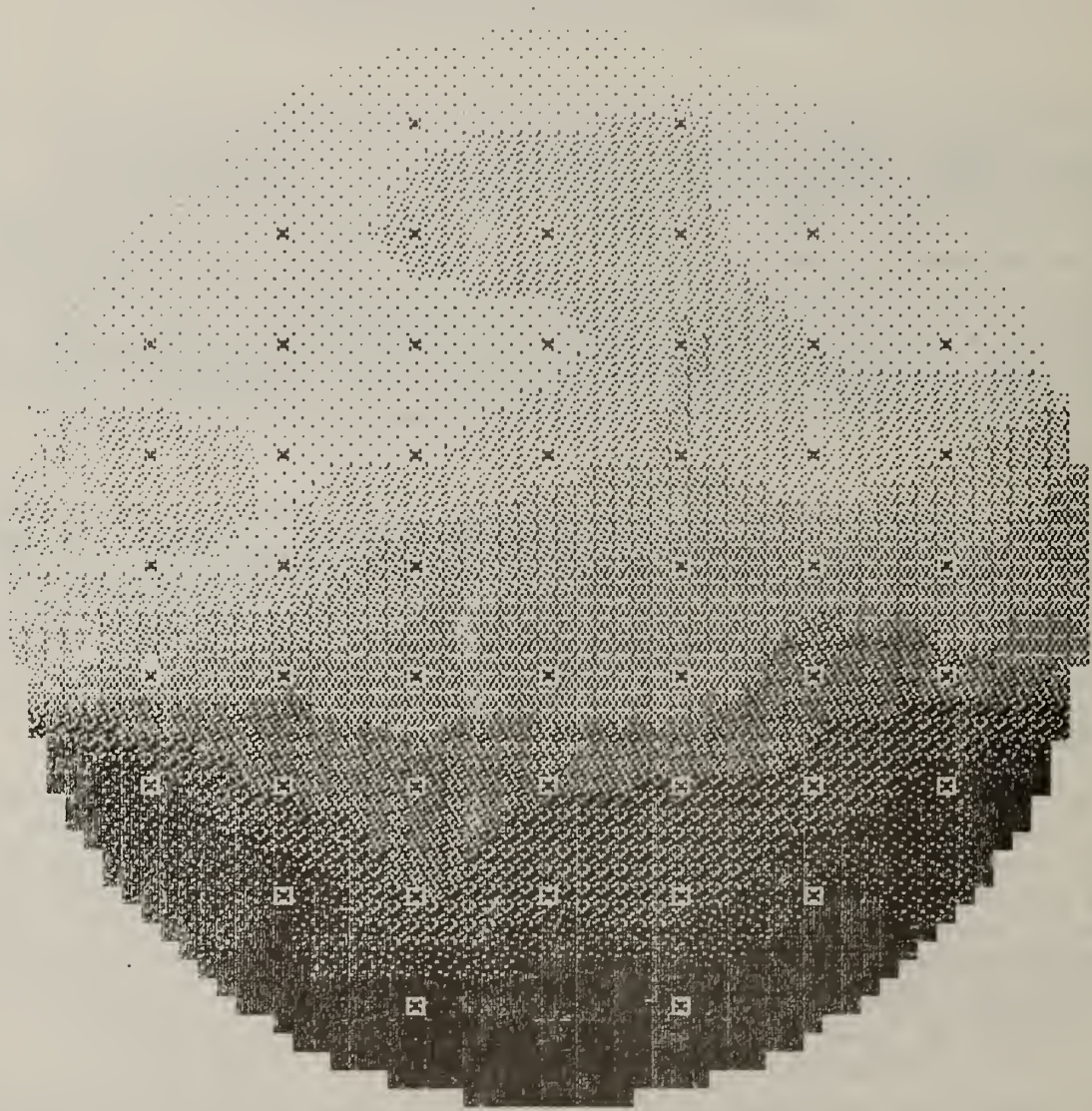EXAMPLE OF A CIRCULAR SHADED MAP MADE WITH THE MP4 COMMAND

Figure 5. Sample circular map.

```
PARAMETER VALUE          # SITES

24. 07178 TO    24. 27020           3

23. 87335 TO    24. 07178           3

23. 67492 TO    23. 87335           4

23. 47650 TO    23. 67492           6

23. 27808 TO    23. 47650           8

23. 07965 TO    23. 27808           4

22. 88123 TO    23. 07965           7

22. 68280 TO    22. 88123          13
```

```
SITES INCLUDED                       48

x  x  x  x        INCLUDED SITES WITHIN SCALE

+  +  +  +        INCLUDED SITES  ABOVE SCALE

-- -- -- --       INCLUDED SITES  BELOW SCALE

SAMPLE MEAN                      23. 28777

SAMPLE STD DEV                    0. 44482

SAMPLE MEDIAN                    23. 24650
```

Figure 6.   Key to map of figure 5.

MP4,P1,P2,P3,P4,P5,P6   ,

where P1 is the diameter of the map in inches, P2 is the scaling mode, P3 is
a flag to allow entry of a map label, P4 is a flag to allow the format of the
map key to be specified, and P5 and P6 are the lowest value in the lightest
shade and highest value in the darkest shade when P2 is 0. P3 through P6
have the same respective meanings as P4 through P7 of the MP2 command. The
meaning of P2 has been changed as discussed in section 5.1 below. The maxi-
mum allowable value of P1 is 8 (inches). The minimum depends on the number
of rows and columns in the data array.

Because of the discrete size of the pixels used to produce the map, the pre-
cise diameter requested is usually not produced. In addition, because of the
discreteness of the pixels and the forced circular boundary, there are some
circumstances in which a map made at a specified diameter may omit points at
the top and bottom or at the right and left edges. Circular shaded maps
should always be examined to see if this has occurred. Selection of another
diameter will usually correct the problem.

The MP4 command is not suitable for use with data measured over a region
which is not approximately circular. For example, when mapping data taken
over a square region, the corners of the DATA array will be clipped. For
this reason, the MP2 command was left in STAT2.

5. New Map and Histogram Options

5.1 New Scaling Mode Interpretation

The scaling mode parameter of the mapping and histogram commands has been
given a slightly different meaning for the case in which the scaling mode is
negative. The scaling mode parameter is P1 for the PLT and HIS commands, P2
for the MP3 and MP4 commands, and P3 for the MP1 and MP2 commands. Formerly,
when the scaling mode was negative, the map or histogram was scaled between
(MEAN + K*SIGMA) and (MEAN - K*SIGMA) where K was the multiple of the sample
standard deviation calculated by the XOL command on its last pass. Under
STAT2 version 1.31, it is now possible in addition to set the multiple of
SIGMA by the ENN command rather than have the multiple be calculated only by
the XOL command. For example, if you want a shaded map in which the upper
and lower bounds of the scaled range are to be (MEAN + 4*SIGMA) and (MEAN -
4*SIGMA), the command sequence might be:

```
ASG filename
REA 3 12
ENN 4
PRS
MP2 6 6 -1 1 0 0 0
END   .
```

It is still necessary to execute PRS prior to invoking a mapping or histogram
request.

5.2 Change in MP3 Contour Map

Under the previous version, the size or diameter of a contour map made with an MP3 command was forced to 8 inches, regardless of what diameter was specified in parameter P1. Now, P1 can be any value in the range 3 to 8 inclusive, and maps of corresponding diameter are produced. Also, excluded sites are now represented in the map by 0's rather than by blanks.

5.3 Maps Inverted

The maps MP1, MP2, MP3, MP4, PLT have been inverted such that row 1 is now the top row of the map rather than the bottom row. This is discussed in greater detail in section 2.

6. New Data Base Features

6.1   New LDB and SDB Command Format

The syntax of the LDB and SDB commands has been completely changed in a manner that now provides greater flexibility in selective listing of a data base and selective calculation of the sample correlation coefficient. Basically, the user specifies which portion of the data base is to be listed, or the portion of the data base to be correlated against the reference data sample using keywords, key values, and key value ranges. The seven regular keywords are PATTERN, LOT, WAFER, DEVICE, PCODE, ENTRY, and DATE. One or more of these keywords might appear on a command line, each keyword followed by one or more key values or key value ranges. For example, to list data from a particular wafer or set of wafers, a user might type one of the following command lines:

```
LDB WAFER 7
LDB WAF 7 42 12 57 112 3002 194
LDB W 7-15
LDB W 7-15 23-48
LDB WAFER 46-49 22 7-15 67 921 1000-1010
```

Note that any number of key values or key value ranges or both may follow the keyword WAFER, that "-" is used to indicate a range, that key values or ranges do not have to be in ascending numerical order, and that WAFER may be abbreviated to the number of letters which uniquely defines it among the other keywords (including the four additional keywords defined below). However, any additional letters beyond the minimum abbreviation must be correct. Two other rules: there must be no space preceding or following the "-" range indicator, and there must be no separators other than spaces between key values or key value ranges. When an LDB command is entered, STAT2 makes a pass through the data base, examines every entry, and lists every entry which matches the specification of the command line.

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It may be desirable to list or search entries which have not only a particular wafer number but also a particular device number. The command to perform such a search might be:

SDB WAFER 2 45 13 DEVICE 55-59

The keywords may be combined in any manner on a command line, so long as the command does not exceed 72 characters in length and there are no repeated keywords in a command line.

The ENTRY keyword allows a user to specify the serial entry number or numbers of the entry or entries to be listed.

The DATE keyword has different syntax from the other regular keywords. A date value may be specified in two ways:

    dd-mmm-yy   or   mm/dd/yy   ,

such as

    18-APR-83   or   4/18/83   .

If a range of dates is to be specified, the dates representing the ends of the range must be separated by a "-" range indicator. Any number of date values or date value ranges may be included on the command line, in combination with other keyword specifications, as long as other syntax rules (such as command length) are not violated.

There are three additional keywords which have no key values associated with them. They are ALL, OR, and VALUES.

The ALL keyword signifies that all data base entries are to be listed (LDB ALL) or are to be used in sample correlation coefficient calculations against the reference data sample (SDB ALL). A warning message is printed if ALL appears on the same command line as one of the seven regular keywords given above. In such a case all entries are listed or searched.

The OR keyword is used when it is desired to list or correlate data base entries in which any of the specifications of a command line are satisfied. For example, the interpretation of the command

SDB LOT 13 DATE 5-JAN-83

is "calculate the sample correlation coefficient of all entries which have 13 in their LOT field AND which were entered into the data base on January 5, 1983." By comparison, the interpretation of the command

SDB LOT 13 OR DATE 5-JAN-83

is "calculate the sample correlation coefficient of all entries which have EITHER 13 in their LOT field OR were entered into the data base on January 5,

1983." The OR keyword may precede any of the other keywords in the command line or may come at the end of the command line.

The VALUES keyword has meaning only for the LDB command and causes an error when used in an SDB command line. It causes the data values to be listed along with the directory information. It may precede any of the other key-words in the command line or may come at the end of the command line.

There is one other keyword which is used only with the SDB command and causes an error when used in an LDB command line. The COEF keyword allows the user to specify a minimum correlation coefficient below which printing of the correlation coefficient is suppressed. This capability was contained in the sixth parameter of the SDB command under the previous version. Under the new version, the command

SDB ALL COEF 0.7

causes the sample correlation coefficient to be calculated for all data base entries against the reference data sample, but only those instances in which the sample correlation coefficient magnitude is 0.7 or greater are reported (logged). COEF must have only a single key value not exceeding 1.0 associ-ated with it. If the COEF keyword is omitted, all results of sample correla-tion coefficient calculations are reported.

Because internally STAT2 uses LDB in its previous form, that command has been kept but under the name LEN (for List ENtry). It has the same syntax as LDB did under version 1.01. For example,

LEN 3 45 0

causes all entries to be listed having entry numbers in the range 3 to 45 inclusive. The command

LEN 14 - 1

causes all entries having entry numbers beginning at 14 through end of file to be listed along with the data values. LEN may still be useful in in-stances where a contiguous range of entries or a single entry is to be listed. LEN can go directly to the desired entries and list them, whereas LDB searches the entire data base for entry numbers which match and therefore takes longer to execute.

6.2 Data Base Sample Size

Under the previous version, it was not possible to include more than 256 sites in a data sample to be stored in a data base. It is now possible to include up to 1024 sites in a data sample. In order to make this change, it was necessary to increase the size of the NDAT field in the data base label file. Therefore, a data base made under the previous version must be altered if it is to be usable by version 1.31 of STAT2. A program, command file, and

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help file to update a data base are given in Appendices I, II, and III. This updating must be done once and only once to all old data bases, that is, those data bases which were created using the CRDB program issued with version 1.01 of STAT2, prior to writing to them or reading from them with version 1.31 of STAT2. Data bases which are created using the CRDB program issued with version 1.31 of STAT2 need not and should not be updated.

7. Other Changes

7.1 The ERM Command

The ERM command is used to suppress warning messages. It now serves an additional purpose. When ERM,0 is executed, subsequent executions of WDB and GET do not list the data values but give only the directory information. Printing of these data values can be resumed by typing ERM,1.

7.2 The OPN and CLO Commands

OPN and CLO are a complementary command pair which enable a user to create a STAT2 command file while executing STAT2. A user who, while using STAT2, realizes that a certain command sequence is being repeated, can type

OPN file-specifier .

At this point, the normal 'STAT2>' prompt is replaced with an 'ENTER>' prompt and the user may type a sequence of STAT2 commands which are not executed but are written to a new file identified by the file specifier in the OPN command. This is called the file-create mode. No syntax checking is done, and once a line is entered the user has no opportunity to make a correction (other than to type CLO and begin again with a new OPN). The command file creation is terminated by typing CLO in response to the 'ENTER>' prompt. CLO in any other context is an illegal command. The user may then invoke the command file with the MAC command. OPN should not be included as a command within such a file because the MAC command rejects it upon encountering it.

7.3 New Help File Directory Specification

Under the previous version, the directory containing the Help files was named explicitly in subroutine HELP of STAT2. This required a user to modify STAT2 when installing the program or when subsequently moving Help files to another directory. Under version 1.31, the directory name is specified by a VMS ASSIGN command, issued prior to running STAT2, which assigns the name to logical unit 10. An example of such a command is given by:

$ ASSIGN DRB1:[USERNAME.HELPFILES] FOR010 .

This command could be put in the LOGIN.COM file of all STAT2 users.

8.   Error Messages

Following is an alphabetical list of error messages which are present in version 1.31 but were not included in version 1.01. Some error messages have been removed as a result of additional flexibility built into the program, but instances of this are not included in this documentation. Lower case letters in the messages represent alphanumeric characters which would appear in the actual messages.

*** AMBIGUOUS KEYWORD: 'kkkkkkkk'

A keyword in an LDB or SDB command has been abbreviated to the extent that it does not uniquely define a known keyword. Use additional characters in the abbreviation.

*** CLO MUST BE PRECEDED BY OPN

A CLO command has been issued while not in the file-create mode.

*** COEF KEYWORD ILLEGAL IN LDB COMMAND

A COEF keyword appears in an LDB command line.

*** COMMAND NOT APPLICABLE TO NON-PERIODIC DATA

A command has been entered which is not legal when processing data read using STAT2 format 5 (random test site locations). A list of these commands is given at the end of section 3.2.

*** DATE SPECIFICATION EXTENDS BEYOND BYTE 72

In reading the DATE specification of an LDB or SDB command line, the specification extended beyond the 72-byte length of the command line.

*** DIAM MUST BE BETWEEN 3 AND 8

An illegal diameter specification has been given in the MP3 command.

*** ERROR IN DAY OR MONTH

A month greater than 12 or day greater than 31 has been included in a DATE specification of an LDB or SDB command.

!!! EXCESS KEYWORDS IN ADDITION TO 'ALL'

Other keywords in addition to ALL have been included in an LDB or SDB command line creating a redundancy. The ALL keyword dominates and causes listing or searching of all entries.

!!! HELP FILE COULD NOT BE OPENED

Either a directory has not been assigned to logical unit 10 or the
directory which has been assigned does not contain the default help file
HEL.HLP.

*** ILLEGAL CHARACTER 'c' IN POSITION i

An illegal character has been detected in an LDB or SDB command line.
The character may be a comma or semicolon or it could be a letter or
digit which is illegal in its particular context.

*** ILLEGAL OPN OR MAC COMMAND

An OPN or MAC command has been encountered while executing a macro
command file.

*** ILLEGAL .SAD FILE

An error occurred in processing the .SAD file during a format 5 read.
Either the number of sites was less than 1 or greater than 1024, a row or
column position was not in the range 1 to 32, or there was insufficient
data in the file.

*** ILLEGAL SPECIFICATION FOR MONTH

An illegal three-letter abbreviation of a month has been used in an LDB
or SDB command.

*** ILLEGAL {STEND, DROPIN} ARRAY

An error or inconsistency was detected when processing the .SAD file
during a format 4 read.

*** KEYWORD HAS NO ASSOCIATED VALUES

A keyword which requires one or more key values or key value ranges has
been included in an LDB or SDB command line, but no key values or key
value ranges have been given.

*** NO KEY VALUES SUPPLIED

An LDB or SDB command contains insufficient specifications to permit it
to select entries for listing or searching.

*** NO KEYWORDS IN COMMAND STRING

An LDB or SDB command contains no keywords.

*** PARAMETER 0 HAS MORE THAN 20 CHARACTERS

A number representing a key value of the COEF keyword of the SDB command is represented by more than 20 digits.

*** PLOT DIAMETER TOO LARGE OR TOO SMALL

The diameter specified in the MP4 command is illegal. The maximum allowed diameter is 8 (inches). The minimum depends on the number of rows and columns in the data array.

*** R MUST BE IN THE RANGE 0 TO 1

The value associated with the COEF keyword of the SDB command is outside the range 0 to 1.

*** RANGE INCOMPLETE

A key value range indicator ("-") in an LDB or SDB command is not immediately followed by a digit.

*** REPEATED KEYWORD

A keyword appears more than once in an LDB or SDB command line.

*** STEND ARRAY FAULT IN MP4

This error is not expected to occur and may indicate a portability problem.

*** UNKNOWN KEYWORD: 'kkkkkkkk'

A keyword has been detected in an LDB or SDB command line which is not one of the known keywords.

*** VALUES KEYWORD ILLEGAL IN SDB COMMAND

A VALUES keyword appears in an SDB command line.

Reference

1. Mattis, R. L., *Semiconductor Measurement Technology:* A FORTRAN Program for Analysis of Data from Microelectronic Test Structures, NBS Special Publication 400-75 (July 1983).

```
C
C      PROGRAM UPDATE1
C
C      UPDATES A STAT2 DATA BASE LABEL FILE FROM STAT2 REVISION 1.01 TO
C      REVISION 1.31.  THE DIFFERENCE IS THAT THE NDAT FIELD HAS BEEN
C      EXPANDED FROM I3 TO I4, AND AN ADJACENT RESERVED FIELD HAS BEEN
C      CONTRACTED FROM 4X TO 3X.  OTHER FIELDS ARE NOT ALTERED.
C
       BYTE DATE(9),TIME(8)
       INTEGER TITLE(9)
       INTEGER ENT,DLT,PTR,PAT,WAF,DEV,PCODE
C
C      OPEN OLD LABEL FILE.
C
       OPEN (UNIT=27,STATUS='OLD',ERR=10,ACCESS='DIRECT',
      * FORM='FORMATTED',ORGANIZATION='RELATIVE',SHARED,
      * RECL=80,RECORDTYPE='FIXED')
C
C      OPEN NEW LABEL FILE.
C
       OPEN (UNIT=37,STATUS='NEW',ERR=20,ACCESS='DIRECT',
      * FORM='FORMATTED',ORGANIZATION='RELATIVE',SHARED,
      * RECL=80,RECORDTYPE='FIXED')
C
C      COPY FIRST RECORD.
C
       READ (27'1,1) TITLE,ISPC,LASTLR,LASTDR
       WRITE (37'1,1) TITLE,ISPC,LASTLR,LASTDR
1      FORMAT (10X,9A4,2X,I3,1X,I5,1X,I6)
C
C      COPY LABEL RECORDS UNTIL END-OF-FILE ENCOUNTERED.
C
       LREC=2
2      READ (27'LREC,3,ERR=50) ENT,DLT,PTR,NDAT,PAT,LOT,WAF,DEV,PCODE,
      * DATE,TIME
3      FORMAT (1X,I5,A1,I6,I3,4X,I3,I3,I3,I4,I4,2X,9A1,1X,8A1)
       WRITE (37'LREC,4) ENT,DLT,PTR,NDAT,PAT,LOT,WAF,DEV,PCODE,
      * DATE,TIME
4      FORMAT (1X,I5,A1,I6,I4,3X,I3,I3,I3,I4,I4,2X,9A1,1X,8A1)
       LREC=LREC+1
       GOTO 2
C
C      PRINT MESSAGE FOR TERMINATION.
C
50     LREC=LREC-1
       WRITE (6,51) LREC
51     FORMAT (1X,'PROGRAM TERMINATION -- ',I5,' RECORDS CONVERTED')
       GOTO 60
```

```
C
C     IF ERROR OPENING FILES.
C
10    WRITE (6,11)
11    FORMAT (1X,'*** ERROR OPENING OLD LABEL FILE')
      GOTO 60
20    WRITE (6,21)
21    FORMAT (1X,'*** ERROR OPENING NEW LABEL FILE')
60    STOP
      END
```

Appendix II: Listing of UPDATE1.COM

```
$ !
$ ! File UPDATE1.COM
$ !
$ ASSIGN 'P1' FOR027
$ ASSIGN 'P1' FOR037
$ RUN UPDATE1
```

File UPDATE1.HLP

UPDATE1 is a Fortran program and VMS command file to update a STAT2 data base
label file from STAT2 version 1.01 to STAT2 version 1.31. The difference is
that the NDAT field (number of data points in the sample) has been expanded
from three digits to four. The data base data file is not affected by going
to the higher version.

To execute the program, type:

@UPDATE1 file-specifier

where 'file-specifier' is the file specifier (including directory if not the
default directory, and including the extension) of the data base label file.
The program reads the old label file and writes a new label file having the
same file specifier but a version number one greater than the old label file.
When the program is finished, it prints a message giving the number of
entries converted and exits. The user should verify that this number is
correct by comparing it with the LASTLR field of the first label record.
Once this verification is done, the old label file may be deleted by
purging.

If an error occurs in trying to open either of the label files, a message is
printed as

*** ERROR OPENING OLD LABEL FILE   or
*** ERROR OPENING NEW LABEL FILE   .

U.S. DEPT. OF COMM. **BIBLIOGRAPHIC DATA** **SHEET** (See instructions)	1. PUBLICATION OR REPORT NO. NBSIR 83-2779	2. Performing Organ. Report No.	3. Publication Date November 1983

4. TITLE AND SUBTITLE

Release Notes for STAT2 Version 1.31:   An Addendum to NBS Special Publication 400-75

5. AUTHOR(S)
R. L. Mattis and R. Zucker

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions) NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234	7. Contract/Grant No. 8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

10. SUPPLEMENTARY NOTES

[x] Document describes a computer program; SF-185, FIPS Software Summary, is attached.

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 document describes the changes which have been made in the STAT2 computer program. The new version contains several new features which provide a more powerful data base capability, improved displays, and greater compatibility with the automatic tester. In going from the original version 1.01 to version 1.31, the DATA array has been redefined and new REA command formats have been added to be compatible with new data acquisition equipment. A new circular shaded map has been added which gives a more realistic representation of data variation over a wafer surface. New map and histogram scaling options allow greater flexibility in specifying the scale of data displays. A new format for two data base commands allows greater flexibility in selectively listing and correlating data base entries. The capability has been added for eliminating some unwanted printout, and for creating macro command files within a STAT2 run. Finally, a new method of specifying the directory containing the Help files makes STAT2 easier to install. Following the description of the changes is an annotated listing of new error messages.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

ATE; computer program; contour map; data base; outlier; process validation wafer; statistical analysis; two-dimensional map; wafer map.

13. AVAILABILITY [x] Unlimited [ ] For Official Distribution. Do Not Release to NTIS [ ] Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. [x] Order From National Technical Information Service (NTIS), Springfield, VA. 22161	14. NO. OF PRINTED PAGES 26 15. Price $8.50

FEDERAL INFORMATION PROCESSING STANDARD SOFTWARE SUMMARY

01. Summary date			02. Summary prepared by *(Name and Phone)*	03. Summary action		
Yr.	Mo.	Day	Richard L. Mattis (301) 921-3621	New	Replacement	Deletion

01. Summary date
Yr.	Mo.	Day
8 3	0 9	0 1

02. Summary prepared by *(Name and Phone)*
Richard L. Mattis (301) 921-3621

05. Software title
Release Notes for STAT2 Version 1.31: An Addendum to NBS Special Publication 400-75

04. Software date
Yr.	Mo.	Day
8 3	0 9	0 1

03. Summary action

New ☐ Replacement ☒ Deletion ☐

Previous Internal Software ID

07. Internal Software ID
STAT2

06. Short title

08. Software type

☐ Automated Data System
☒ Computer Program
☐ Subroutine/Module

09. Processing mode

☒ Interactive
☐ Batch
☐ Combination

10. Application area

General

☐ Computer Systems Support/Utility
☒ Scientific/Engineering
☐ Bibliographic/Textual

☐ Management/Business
☐ Process Control
☐ Other

Specific

Analysis of Integrated Circuit Process Validation Wafer Test Data

11. Submitting organization and address

Semiconductor Devices and Circuits Division
National Bureau of Standards
Washington, DC 20234

12. Technical contact(s) and phone

Richard L. Mattis
(301) 921-3621

13. Narrative

The program performs the following functions: read data as a two-dimensional array in several formats; calculate mean, standard deviation, median; identify outliers; calculate replacement values for outliers; make gray tone, numerical, and contour data maps on a line printer; make a numerical map on the user's terminal; make a histogram on a line printer; construct a data base for making correlations among various data sets; search said data base using several selective keys. The package includes a set of help files callable from the program.

14. Keywords

Correlation coefficient; data management; outlier; process validation wafer; statistical analysis; two-dimensional arrays; wafer map.

15. Computer manuf'r and model	16. Computer operating system	17. Programing language(s)	18. Number of source program statements
DEC VAX 11/780	VMS 3.3	FORTRAN	13154

19. Computer memory requirements	20. Tape drives	21. Disk/Drum units Disk needed for map scratch file, data input, help file	22. Terminals
630 KB	None		1 video or hard copy

23. Other operational requirements

24. Software availability

Available ☒   Limited ☐   In-house only ☐

25. Documentation availability

Available ☒   Inadequate ☐   In-house only ☐

The user's manual is available and consists of NBS Spec. Publ. 400-75 and NBSIR 83-2779.

26. FOR SUBMITTING ORGANIZATION USE