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ABSTRACT

The DoD method allows to derive an estimate of the standard deviation for data being inhomogeneous from the statistical point of view. The evaluation of data using DoD does not demand for prior rejection of suspicious values or outlier results. This report includes a comprehensive manual of the computer program DoD and illustrates the handling and functioning of DoD. The DoD manual describes the PC-version 2.0 including its program modules. The theoretical background is given both, in rough outlines in this report and by references describing DoD in full detail. The DoD program package is a menu-guided tool to evaluate up to 200 measurement data. Results are the standard deviation and the median value of these measurement data. As an alternative, conventional evaluation using the Bartsch-outlier criterion is also possible and makes the user able to compare the result to that gained with DoD. The measurement data can be displayed numerically and by graphic, as well. The results can be displayed numerically. In addition, the distribution of differences can be displayed by graphic. Therefore, a comfortable graphical output utility is attached to DoD Version 2.0. DoD Version 2.0 is written in FORTRAN 77 and the program modules are compiled and linked with the Ryan Mc-Farland Compiler. The DoD Graphical Utility uses the PLOT88 Library of Plotworks, Inc..

Das DoD-Handbuch

Die DoD-Methode ermöglicht die Ableitung eines Schätzwertes für die Standard-Abweichung von Daten, die - vom Standpunkt der Statistik gesehen - inhomogen sind. Die Auswertung von Daten mit Hilfe der DoD-Methode erfordert keinen vorherigen Ausschluß von verdächtigen Werten oder Ausreißer-Ergebnissen. Dieser Bericht stellt ein ausführliches Handbuch des PC-Programmes DoD dar und illustriert seine Handhabung und Funktion. Das DoD-Handbuch beschreibt Version 2.0 mit seinen Programm-Modulen. Der theoretische Hintergrund wird in diesem Bericht skizziert, für detaillierte Information wird auf Referenzen verwiesen. Das Programm-Paket DoD ist ein menü-geführtes Werkzeug, mit dem man bis zu 200 Meßwerte auswerten kann. Die Auswerte-Ergebnisse sind die Standardabweichung und der Zentralwert (Median) der Meßwerte. Alternativ wird die konventionelle Auswertung mit Hilfe des Bartsch-Ausreißerkriteriums offeriert, die dem Benutzer den Vergleich mit den Ergebnissen der DoD-Methode ermöglicht. Die Meßwerte selbst können sowohl numerisch als auch graphisch dargestellt werden. Die Auswerte-Ergebnisse können numerisch dargestellt werden. Darüber hinaus kann die Verteilung der Differenzen graphisch dargestellt werden. Dafür wurde eine komfortable Graphik-Ausgabeeinheit in die DoD-Version 2.0 eingebunden. Die DoD-Version 2.0 ist in FORTRAN 77 geschrieben und die Programm-Modulen wurden mit dem Ryan Mc-Farland Compiler übersetzt und gebunden. Die DoD-Graphik-Einheit benutzt die PLOT88-Bibliothek von Plotworks, Inc..

Contents

1. Introduction

1.1 DoD Summary

This is a short description of the main features of the PC program DoD, Version 2.0.

The DoD method (Distribution of Differences) allows to derive an estimate of the standard deviation for data being inhomogeneous from the statistical point of view. DoD does not demand for prior rejection of suspicious values or outlier results. For the theoretical background please refer to KfK 4721 (EUR 11398 EN), "The DoD Method", published in May, 1990.

The estimate of the standard deviation obtained by the DoD method is nearly independent from the magnitude of one single outlier value which belongs to the data group considered. But the quantile of outlier values should not exceed 20% of the data. Assuming that the considered data may contain at least one outlier value, the DoD method should not be applied to data containing less than five values.

For technical reasons this PC version of DoD is limited to 200 values at maximum which can be evaluated using this program. From those 200 values, 200*(200-1)/2=19,900 differences have to be calculated and also to be sorted in order to obtain the DoD estimate of the standard deviation. Compared to version 1.0, the run time for this evaluation was considerably reduced by the use of new and faster algorithms. The run time in performing DoD evaluation of 200 measurement values is now in an order of magnitude of seconds (this was tested using a PC equipped with a processor of the type 386).

1.2 Generalities

DoD Version 2.0 is written in FORTRAN 77 and the program modules are compiled and linked with the Ryan Mc-Farland Compiler. The DoD Graphical Utility uses the PLOT88 Library of Plotworks Ltd.. The DoD Menu Guide uses the 'Ask Utility' of NORTON Utilities.

1.3 System Support

The DoD numerical program modules and the included DoD graphic utilities need a minimum of hardware system configuration:

a) a computer system (AT-compatible) with at least 256 kByte memory, including a mathematical co-processor,

b) a Hard Disk drive,

c) a Floppy Disk Drive (at least 360 kByte),

d) an EGA/VGA graphic adapter,

e) a graphical display,

f) an output device (matrix printer/laser printer)

g) a PC-DOS version 3.0 or higher.

2. How to Install and to Start the Program DoD

First of all, it should be checked that the following data sets are available on the directory DOD of the original DoD disk:

- ASK.EXE
- BART.EXE
- CDEVICE.EXE
- DEVICE.EXE
- DODA.EXE
- DODM.EXE
- EXPOBART.EXE
- EXPORDAT.EXE
- EXPORDOD.EXE
- GDATA.EXE
- GDODA.EXE
- IMPORT.EXE
- PLOTPARM.EXE
- RET.COM

and that the following data sets are available on the associated subdirectory WS (working space) of the original DoD disk:

- DOD.BAT
- RO.DAT

For optimization of the performance of the DoD program modules, the DoD program has to be installed on the hard disk of the user's computer system. This can be easily performed from the original DoD disk by simple COPY commands to an appropriate directory.

For example: **copy a:\dod*.* c:\dod\.**

and: **copy a:\dod\ws*.* c:\dod\ws\.**

The sub-directory WS serves for storaging data sets to be evaluated. The program DoD can be started from sub-directory WS using the command **dod**.

4 Chapter 2: Install and Start DoD

During the use of the DoD program the following data files will be generated:

- PLOTPARM.INP	actual list of plot parameters
- DIRLST.LST	last dirlist
- DIRLST.BAR	all available '.lba'
- DIRLST.DOD	all available '.ldm'
- 'datafile'.LBA	conventional results using Bartsch
- 'datafile'.LDM	DoD results
- 'datafile'.PDA	DoDA-values for graphic
- OUTDAT	last browse related to Data Set
- OUTDOD	last browse related to DoD
- OUTBART	last browse related to Bartsch
- 'datafile'.HPG	last generated HPGL file (Data or DoDA-values for graphic)

Notice: The term **datafile** stands for the names of input data evaluated.

3. Description of the DoD Menus

The computer program DoD is menu-guided and therefore, it is very user-friendly. This chapter describes the various DoD menus.

3.1 Main Menu

After the command **dod**, the MAIN MENU of the DoD program appears on the screen as follows:

```
DDDDDDD                    DDDDDDD
DD    DD                   DD    DD
DD     DD      ooooo       DD     DD
DD     DD     oo   oo      DD     DD
DD     DD     oo   oo      DD     DD
DD    DD      oo   oo      DD    DD
DDDDDDD        ooooo       DDDDDDD

MAIN MENU:
DoD Evaluation Procedure:
Enter the Number of Your Choice

    1 == Import of Data Files
    2 == DoD Evaluation
    3 == Browse Inputs or Results
    B == Conventional Evaluation Using Bartsch
    D == DoDA Evaluation for Graphic
    Q == Quit the Session

 Your Choice :
```

Choosing one of the options above, the DoD menu-guide system offers various sub-menus to the user.

3.2 Import Menu: Menu 1

Choosing menu '1' the user will be enabled to import data files into the working space (WS) which are stored elsewhere in the user's computer system.

After this, all data sets in WS which are associated with the qualifier 'dat' are listed on the screen (using DoD for the first time, only the supplied data set 'ro.dat' is listed in this case), and the screen shows the following text:

```
DIRECTORY OF C:\DOD\WS

    ro.dat


Program Task:

Import of Data File
===================

Enter Source Name of Data File:
===>
```

Now the program expects the input of the name of a data file to be transferred from anywhere in the user's PC system to the working space of DoD. The input may be as follows:

===>d:\datapool\datafile.dat

This input string may contain 24 characters at maximum from which the name itself (in this example: datafile) must not consist of more than eight characters.

Then, the program transfers the data set 'datafile.dat' from directory 'datapool' of drive 'd:' to the working space. Here, the data set is called 'datafile.dat', and the program returns to the main menu.

Notice: The data set to be transferred must have the qualifier 'dat', and if there already exists in WS a data set called 'datafile.dat' (see the example), the demand will be rejected and the data transfer is terminated.

3.3 DoD Evaluation Menu: Menu 2

With menu '2' the user can perform DoD evaluation of data files being stored in the working space (WS) of the program.

After this, all data sets of WS associated with the qualifier 'dat' are listed on the screen, and the screen shows the following text:

```
Program Task:

Evaluation by the DoD Method.
=============================


    da1.dat   da2.dat   da3.dat   da4.dat   da5.dat
    da6.dat   da7.dat   da8.dat   datafile.dat   ro.dat


Enter File Name of Measurement Series:
===>
```

The complete name of data set has to be given as follows:

===>**datafile.dat**

The name itself (datafile) must not contain more than eight characters.

The program evaluates the data set by the DoD method using the DoDM procedure and shows the result of evaluation on the screen. Furthermore, the program creates a data file called 'datafile.ldm' according to the name of the data set investigated which is complemented by the qualifier 'ldm'. The DoD evaluation results will be written on this data file. Using menu 3, the user is able to browse or to print those numerical results.

Notice: After performing the program run of sub-menu '2', the results of this run remain available in the working space, and the user, therefore, is always able to generate a hardcopy of the evaluation.

3.4 Browse Menu: Menu 3

Notice: Examples of printouts are given in APPENDIX-I (Examples of Results).

Menu '3' serves for numerical or graphical output of data or results either on the screen or directed to the associated print device.

After typing 3, the screen shows the following text:

```
MENU 3:
Browse or Print Inputs or Results;

Select the Output Option by
Typing the Number of Your Choice.

    1 == Browse or Print Numerically
    2 == Browse or Print by Graphic
    E == End and Go to MAIN MENU

Your Choice :
```

3.4.1 Numerical Output Menu: Menu 3.1

Choosing sub-menu '1' for numerical output, the following information appears on the screen:

```
MENU 3.1:
Numerical Output;

Select the Output Option by
Typing the Number of Your Choice.

    1 == Screen
    2 == Printer
    E == End and Go to PREVIOUS MENU

Your Choice :
```

3.4.1.1 Numerical Output on Screen: Menu 3.1.1

Choosing '1' in menu 3.1 (numerical output directed to the screen), the following information appears on the screen:

```
MENU 3.1.1:
Browse Numerically;

Select the Output Option by
Typing the Number of Your Choice.

    1 == Browse Input Data
    2 == Browse DoD Results
    3 == Browse Results Using Bartsch
    E == End and Go to BROWSE or PRINT

Your Choice :
```

In the case of choosing option '1' (browse of input data), all available data sets related to the qualifier 'dat' are listed and the following information appears on the screen:

```
Program Task: Browse or Print Data File

    da1.dat   da2.dat   da3.dat   da4.dat   da5.dat
    da6.dat   da7.dat   da8.dat   datafile.dat   ro.dat


Enter File Name of Measurement Series:
===>
```

The user is requested to type the complete name of an existing data set given above, for example:

===>**da4.dat**

and the requested data set is stored on the data file 'outdat' and then, the contents of 'outdat' are listed on the screen.

In the case of choosing option '2' (browse DoD results), all available data sets related to the qualifier 'ldm' are listed and the following information appears on the screen:

```
Program Task: Browse or Print Data File

    da1.ldm   da2.ldm   da3.ldm   da4.ldm   da5.ldm
    da6.ldm   da7.ldm   da8.ldm   datafile.ldm   ro.ldm


Enter File Name of DoD Results:
===>
```

The user is requested to type the complete name of an existing data set given above, for example:

===>**da5.ldm**

and the requested data set is stored on the data file 'outdod' and then, the contents of 'outdod' are listed on the screen.

In the case of choosing option '3' (browse results using Bartsch), all available data sets related to the qualifier 'lba' are listed and the following information appears on the screen:

```
Program Task: Browse or Print Data File

    da1.lba   da2.lba   da3.lba   da4.lba   da5.lba
    da6.lba   da7.lba   da8.lba   datafile.lba   ro.lba


Enter File Name of Bartsch Results:
===>
```

The user is requested to type the complete name of an existing data set given above, for example:

===>**da8.lba**

and the requested data set is stored on the data file 'outbart' and then, the contents of 'outbart' are listed on the screen.

3.4.1.2 Numerical Output on Printer: Menu 3.1.2

In the case of choosing '2' in menu 3.1 (numerical output directed to the printer), the following information appears on the screen:

```
MENU 3.1.2:
Print Numerically;

Select the Output Option by
Typing the Number of Your Choice.

    1 == Print Input Data
    2 == Print DoD Results
    3 == Print Results Using Bartsch
    E == End and Go to BROWSE or PRINT

Your Choice :
```

and a very similar procedure follows as described for MENU 3.1.1:.

In the case of choosing option '1' (print of input data), all available data sets related to the qualifier 'dat' are listed and the following information appears on the screen:

```
Program Task: Browse or Print Data File

    da1.dat   da2.dat   da3.dat   da4.dat   da5.dat
    da6.dat   da7.dat   da8.dat   datafile.dat   ro.dat


Enter File Name of Measurement Series:
===>
```

The user is requested to type the complete name of an existing data set given above, for example:

===>da4.dat

and the requested data set is stored on the data file 'outdat' and then, the contents of 'outdat' are directed to the print device.

In the case of choosing option '2' (print DoD results), all available data sets related to the qualifier 'ldm' are listed and the following information appears on the screen:

```
Program Task: Browse or Print Data File

    da1.ldm   da2.ldm   da3.ldm   da4.ldm   da5.ldm
    da6.ldm   da7.ldm   da8.ldm   datafile.ldm   ro.ldm

Enter File Name of DoD Results:
===>
```

The user is requested to type the complete name of an existing data set given above, for example:

===>**da5.ldm**

and the requested data set is stored on the data file 'outdod' and then, the contents of 'outdod' are directed to the print device.

In the case of choosing option '3' (print results using Bartsch), all available data sets related to the qualifier 'lba' are listed and the following information appears on the screen:

```
Program Task: Browse or Print Data File

    da1.lba   da2.lba   da3.lba   da4.lba   da5.lba
    da6.lba   da7.lba   da8.lba   datafile.lba   ro.lba

Enter File Name of Bartsch Results:
===>
```

The user is requested to type the complete name of an existing data set given above, for example:

===>**da8.lba**

and the requested data set is stored on the data file 'outbart' and then, the contents of 'outbart' are directed to the print device.

3.4.2 Graphical Output Menu: Menu 3.2

After choosing sub-menu '2' in menu 3 (output by graphic), the following information appears on the screen:

```
MENU 3.2:
Output by Graphic


THE CURRENT OUTPUT DEVICE:   D) COLOR-DISPLAY (EGA/VGA)

Select the Graphical-Output-Routine by
Typing the Number of Your Choice.

    1 == Input Data
    2 == DoDA Graphic
    3 == Change Plot Parameters
    E == End and Go to PREVIOUS MENU

Your Choice:
```

3.4.2.1 Graphical Output of Input Data: Menu 3.2.1

Typing **1** in menu 3.2 (graphical output of input data), the following information appears on the screen:

```
GRAPHIC UTILITY:

THE CURRENT OUTPUT DEVICE:   D) COLOR-DISPLAY (EGA/VGA)

DRAWS THE SERIES OF MEASUREMENTS

    da1.dat   da2.dat   da3.dat   da4.dat   da5.dat
    da6.dat   da7.dat   da8.dat   datafile.dat   ro.dat


ENTER FILE NAME OF MEASUREMENTS
===>
```

and the user is requested to type the name of an existing data set given above, for example:

===>**da8.dat**,

or in this case also simply,

===>**da8**

Then, the requested data set da8.dat is displayed graphically either on the screen, or the output is directed to the print device. The destination of output to the output device depends on the chosen plot parameter to be set in sub-menu '3'. For information, the actual output device is written on the screen (in this example: COLOR-DISPLAY).

Notice: If the print device is not ready or not switched on, the output is automatically directed to the screen (COLOR-DISPLAY) which is the standard output device. If a print output is wanted, the plot parameter has to be set again, after the print device was switched on.

3.4.2.2 Graphical Output of DoDA Values: Menu 3.2.2

Typing **2** in menu 3.2 (graphical output of DoDA values), the following information appears on the screen:

```
GRAPHIC UTILITY:

THE CURRENT OUTPUT DEVICE:  B) HP-LASER-JET & HP-DESK-JET

DRAWS THE SERIES OF DoDA Values

    da1.pda   da2.pda   da3.pda   da4.pda   da5.pda
    da6.pda   da7.pda   da8.pda   datafile.pda   ro.pda


ENTER FILE NAME OF DoDA Values
===>
```

and the user is requested to type the name of an existing data set given above, for example:

===>**da3.dat**,

or in this case also simply,

===>**da3**

Then, the requested data set da3.dat is displayed graphically either on the screen, or the output is directed to the print device. The destination of output to the output device depends on the chosen plot parameter to be set in sub-menu '3'. For information, the actual output device is written on the screen (in this example: HP-LASER-JET & HP-DESK-JET).

3.4.2.3 Change Plot Parameters: Menu 3.2.3

Choosing '3' in menu 3.2 in order to set plot parameters, the following information appears on the screen:

```
MODIFY THE PLOTTING PARAMETER
^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
1 LENGTH OF X-AXIS ===>    7.00
2 LENGTH OF Y-AXIS ===>    5.00
3 REORIGIN X-COORD.===>    1.00
4 REORIGIN Y-COORD.===>    1.50
5 SIZE FACTOR      ===>      1.00
6 LINE WIDTH       ===>  1
7 AXIS COLOR       ===>  2
8 BOX COLOR        ===>  7
9 STATISTIC COLOR  ===>  1
10 BOUNDARY COLOR  ===>  4
11 GRAPHIC-DEVICE  ===> D
    A) NEC/EPSON/LQ1500/IBMPROprinter
    B) HP-LASER-JET & HP-DESK-JET
    C) HP-INKJET
    D) COLOR-DISPLAY    (EGA/VGA)
    E) GRAPHIC DATA FILE (HPGL)
TYPE THE NUMBER 1...11, OR Q FOR QUIT
===>
```

With the parameters 1,2 and 5 the user can control the size of the line graph in the graphical output.

With the parameters 3, and 4 the user can determine the position of the line graph in the graphical output.

With the parameter 6 the user can determine the line width of the line graph.

With the parameters 7 to 10 the user can select the colors of the graphical output for graphical devices with color options.

With the parameter 11 the user can select the graphical output device.

The default values as shown in the parameter list above should be used as long as possible.

With parameters 1 to 4 the values are scaled in inches.

With parameters 5 and 6 help is given by the limits of range.

With parameters 7 to 10 help is given by the code list of colors.

Choosing 'Q' in order to quit the sub-menu of plot parameters, the user is prompted for saving or not the plotting parameters as shown.

3.5 Conventional Evaluation Menu: Menu B

Menu **'B'** offers the user as an alternative the possibility to calculate the standard deviation conventionally using in advance the Bartsch-outlier criterion. Thus, the user is in a position to compare the estimate of the standard deviation evaluated by the DoD method to an estimate derived in the conventional way.

After typing **b** or **B**, all data sets of WS associated with the qualifier 'dat' are listed on the screen, and the screen shows the following text:

```
Program Task:

Evaluation by the Bartsch Criterion.
====================================


    da1.dat   da2.dat   da3.dat   da4.dat   da5.dat
    da6.dat   da7.dat   da8.dat   datafile.dat   ro.dat


Enter File Name of Measurement Series:
===>
```

The complete name of data set has to be given as follows:

===>**datafile.dat**

The name itself must not contain more than eight characters.

The program evaluates the data set in the conventional way computing mean value and standard deviation. Then, the same calculations are performed after rejection of that measurement value which is most suspicious to be an outlier result. Using the Bartsch-outlier criterion, now it will be decided whether or not this value is an outlier. In case of being an outlier, the next suspicious value will be treated in the same way. This procedure will be continued until the last decision amounts to 'the suspicious value belongs to the remaining data set and is not an outlier value'.

The final result will be kept on the basis of this situation. The program creates a data file called 'datafile.lba' according to the name of the data set investigated which is complemented by the qualifier 'lba'. The final result of conventional evaluation will be written on this data file. Using menu 3, the user is able to browse or to print such numerical results.

Notice: After performing the program run of sub-menu 'B', the results of this run remain available in the working space, and the user, therefore, is always able to generate a hardcopy of the evaluation.

3.6 DoDA Graphic Menu: Menu D

Using Menu 'D' the user can start an evaluation procedure which calculates all differences of the data to each other. This program part generates a data set serving for an appropriate graphical display of DoD evaluation.

After typing **d** or **D**, all data sets of WS associated with the qualifier 'dat' are listed on the screen, and the screen shows the following text:

```
Program Task:

Determination of DoDA Values for Graphic
========================================


    da1.dat   da2.dat   da3.dat   da4.dat   da5.dat
    da6.dat   da7.dat   da8.dat   datafile.dat   ro.dat


Enter File Name of Measurement Series:
===>
```

The complete name of data set has to be given as follows:

===>datafile.dat

The name itself must not contain more than eight characters.

The program calculates all n*(n-1)/2 differences which can be established from the original measurement values, arranges these differences in increasing order, and combines each difference with a quantile according to the whole of differences. The program creates a data file called 'datafile.pda' according to the name of the data set investigated which is complemented by the qualifier 'pda'. The results of DoDA values for graphic will be written on this data file. Using menu 3, the user is able to browse or to print these results by graphic.

In the case the number of differences to be established is greater than 200, the program first reduces the number of difference values to less than or equal to 200, and then the reduced number of values will be stored on the data file 'datafile.pda'.

Notice: After performing the program run of sub-menu 'D', the results of this run remain available in the working space, and the user, therefore, is always able to generate a hardcopy of the evaluation.

3.7 Quit Session Menu: Menu Q

In order to complete the DoD session, the user has to choose 'Q' in the main menu.

4. Structure of the Input Data Set

The data format is free. But, the structure of the data must be in such a way that the data to be evaluated are given line by line as first values. All evaluation procedures (menu 2, B, D) and also the browse option (menu 3, browse or print input data) read the data line by line considering only the first value of each line.

In order to illustrate the structure of the input data, please refer to the data set 'ro.dat' which is also supplied to the user.

Chapter 4: Structure of Input Data

5. Error Messages

There are only a few possibilities to handle DoD in an incorrect manner, because the user is menu-guided. Examples of incorrect use of DoD may be the missing of initial data sets, incorrect input of data set names, browse or print of results which are not yet evaluated, or request for printout, although the printer is not switched on. In those cases, the program system generates self-explanatory messages which give the user advice how to proceed correctly.

Such messages may be:

- Run Time File is Missing!
- Data File is Missing!
  Goto Import of Data Files First!
- Data File is Missing!
  Run DoD Evaluation First!
- Data File is Missing!
  Run Conventional Evaluation Using Bartsch First!
- Data File is Missing!
  Run DoDA Evaluation for Graphic First!
- Printer not Ready or not Attached!
- File Name Not Found!

The last message appears in the case an typing error has taken place. Then, the user gets the opportunity twice to input correctly the desired data set name. This does not hold for the import menu (menu 1) where the program returns immediately back to the main menu. In all other menus (2, 3, B and D, as well) the program returns to the main menu after three mistakes took place.

6. Further Aspects

6.1 Maximum Number of Values

The maximum number of values to be evaluated by the PC-program DoD is limited to 200 values. This was decided with respect to the in-situ applicability of this program. Furthermore, this range was sufficient for all evaluations up to now. But if there are any problems with this restriction that means one wants to evaluate more than 200 values, the user is pleased not to hesitate to contact one of the authors. Then, the authers are anxious to supply the user with a version of DoD which is able to evaluate the desired number of values.

6.2 Graphical Data File with HPGL-Format

The possibility to choose the 'Graphical Data File' option in the Menu 3.2.3 enables the user of DoD to create an graphical data file in HPGL-Format (Hewlet-Packard Graphic Language).

The HPGL data file is stored in the sub-directory WS with the name:

'datafile'.HPG

This HPGL data file can be imported to the text editor 'WordPerfect 5.1' for further wordprocessing applications. Furthermore, these HPGL data files can be send using the DOS copy command to the port (lpt1:, com1:) if there is connected a Hewlett-Packard plotter (HP7475A; HP7470A).

Notice: This HPGL data file may contain either the graphic of measurement data or the graphic of DoDA-values depending on the last performance in menu 3.2 after choosing 'E' for parameter 11 in sub-menu 3.2.3. This transfer to the text editor has to be done separately for each kind of graphic data if both shall be imported, measurement data and DoDA-values, as well.

7. Theoretical Background

Step by step, the DoD method was developed in the Karlsruhe Nuclear Research Center in the last fifteen years (/1/ to /10/).

Thereby, the conventional way of calculating mean value and standard deviation was used as an alternative. In order to obtain homogeneity of the data material before calculations, an outlier criterion had to be used. Due to the experiences gained with the performance of the IDA-80 Program /11/, the Bartsch-outlier criterion /12/ was chosen.

Both, conventional evaluation and evaluation using the DoD method were implemented in the PC program DoD.

Thus, the PC program DoD enables the user to calculate standard deviations of groups of data even if those contain outliers, and to compare these result to each other.

The **DoD method** uses the total of all n(n-1)/2 absolute differences obtainable from **n** measurement values (realizations of random variables) in order to derive an estimate of the standard deviation. Furthermore, the median value is determined in order to normalize the result by calculating the relative standard deviation. For more detail see /10/. Here the method is described in full detail and examples are given for use.

Another possibility is the **conventional evaluation** of the data by means of the analysis of variances using the Bartsch criterion. The Bartsch criterion is used at least once. In case of no outlier, the final result of conventional evaluation relates to the first computation comprising all values. In case an outlier was found, the program searches for the next suspicious value and tests that value whether or not it has to be rejected according to the Bartsch criterion. This procedure will be repeated, until the suspicious value considered has not to be rejected. In this case, the final result of conventional evaluation relates to that computation run which is next to the last one.

Also in this program part, the median value of the measurement data is determined. Therefore, the user is able to compare the calculated mean value to the median value.

REMARK:

If there is any problem, please don't hesitate to contact the authors U. Bicking, W. Golly or R. Seifert, c/o Karlsruhe Nuclear Center, P.O.B. 3640, Department IAI, (D-7500) KARLSRUHE 1, Telephone 0049-7247-82/3971, 2292 or 4411. We would appreciate any comment or proposal from user's side which might improve the use of the program.

8. References

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/9/ W. Beyrich, W. Golly, "Evaluation of IDA-80 Data by the DoD Method", KfK 4157/EUR 10533EN, Karlsruhe (1989)

/10/ W. Beyrich, W. Golly, N. Peter, R. Seifert, "The DoD Method", KfK 4721/EUR 11398EN, Karlsruhe (1989)

/11/ W. Beyrich, W. Golly, G. Spannagel, P. De Bievre, W. Wolters, "The IDA-80 Measurement Evaluation Programme on Mass Spectrometric Isotope Dilution Analysis of Uranium and Plutonium, Volume I: Design and Results", KfK 3760/EUR 7990e, Karlsruhe (1984)

/12/ H.J. Bartsch, "Handbook of Mathematical Formulas", Academic Press Inc., New York (1974)

9. APPENDIX-I / Examples of Results

9.1 Numerical Results

```
****************************************

        LIST OF DATA EVALUATED:

****************************************

    Name of Data File:    ro.dat

****************************************
    No.        Value
****************************************
     1         0.199000
     2         0.300000
     3         0.400000
     4         0.500000
     5         0.599000
     6         0.699000
     7         0.800000
     8         0.899000
     9         0.999000
    10         0.999000
    11         0.999000
    12         0.999000
    13         0.999000
    14         0.999000
    15         0.999000
    16         1.000000
    17         1.000000
    18         1.000000
    19         1.000000
    20         0.999000
    21         1.000000
    22         0.999000
    23         1.001000
    24         1.000000
    25         1.000000
    26         1.000000
    27         1.000000
    28         1.001000
    29         1.000000
    30         1.000000
    31         1.000000
    32         1.000000
    33         0.999000
    34         1.000000
    35         1.000000
    36         0.999000
    37         0.999000
    38         0.999000
    39         0.999000
    40         1.000000
    41         1.000000
    42         0.999000
    43         1.001000
    44         1.000000
    45         1.000000
    46         1.000000
    47         1.000000
    48         1.000000
    49         0.999000
    50         0.999000
****************************************
```

```
**********************************************************

        NUMERICAL RESULTS OF DoD EVALUATION:

**********************************************************

   Name of Data File:       ro.ldm

**********************************************************

   FINAL RESULT OF DoD EVALUATION:

**********************************************************

   NUMBER OF OBSERVATIONS =     50

   1S-STANDARD DEVIATION  =   0.001000

   1S-RELATIVE STANDARD DEVIATION (%)
   BASED ON MEDIAN VALUE  =   0.100049

**********************************************************

            MEDIAN VALUE  =   0.999500

**********************************************************
```

```
************************************************************

   NUMERICAL RESULTS OF CONVENTIONAL EVALUATION
       USING THE BARTSCH-OUTLIER CRITERION:

************************************************************

   Name of Data File:        ro.lba

************************************************************

   FINAL RESULT OF CONVENTIONAL EVALUATION:

************************************************************

   THE DATA GROUP CONTAINS OUTLIERS

   NUMBER OF ELEMENTS =      50

   WITHOUT NUMBERS :     1   2   3   4   5   6   7   8

   NUMBER OF VALUES CONSIDERED =    42

   NO.      INPUT     REJECTED     SORTED

    1     0.199000    <==        0.199000
    2     0.300000    <==        0.300000
    3     0.400000    <==        0.400000
    4     0.500000    <==        0.500000
    5     0.599000    <==        0.599000
    6     0.699000    <==        0.699000
    7     0.800000    <==        0.800000
    8     0.899000    <==        0.899000
    9     0.999000               0.999000
   10     0.999000               0.999000
   11     0.999000               0.999000
   12     0.999000               0.999000
   13     0.999000               0.999000
   14     0.999000               0.999000
   15     0.999000               0.999000
   16     1.000000               0.999000
   17     1.000000               0.999000
   18     1.000000               0.999000
   19     1.000000               0.999000
   20     0.999000               0.999000
   21     1.000000               0.999000
   22     0.999000               0.999000
   23     1.001000               0.999000
   24     1.000000               0.999000
   25     1.000000               0.999000
   26     1.000000               1.000000
   27     1.000000               1.000000
   28     1.001000               1.000000
   29     1.000000               1.000000
   30     1.000000               1.000000
   31     1.000000               1.000000
   32     1.000000               1.000000
   33     0.999000               1.000000
   34     1.000000               1.000000
   35     1.000000               1.000000
```

36	0.999000	1.000000
37	0.999000	1.000000
38	0.999000	1.000000
39	0.999000	1.000000
40	1.000000	1.000000
41	1.000000	1.000000
42	0.999000	1.000000
43	1.001000	1.000000
44	1.000000	1.000000
45	1.000000	1.000000
46	1.000000	1.000000
47	1.000000	1.000000
48	1.000000	1.001000
49	0.999000	1.001000
50	0.999000	1.001000

MEAN VALUE = 0.999667

1S-STANDARD DEVIATION = 0.000612

1S-RELATIVE STANDARD DEVIATION (%)

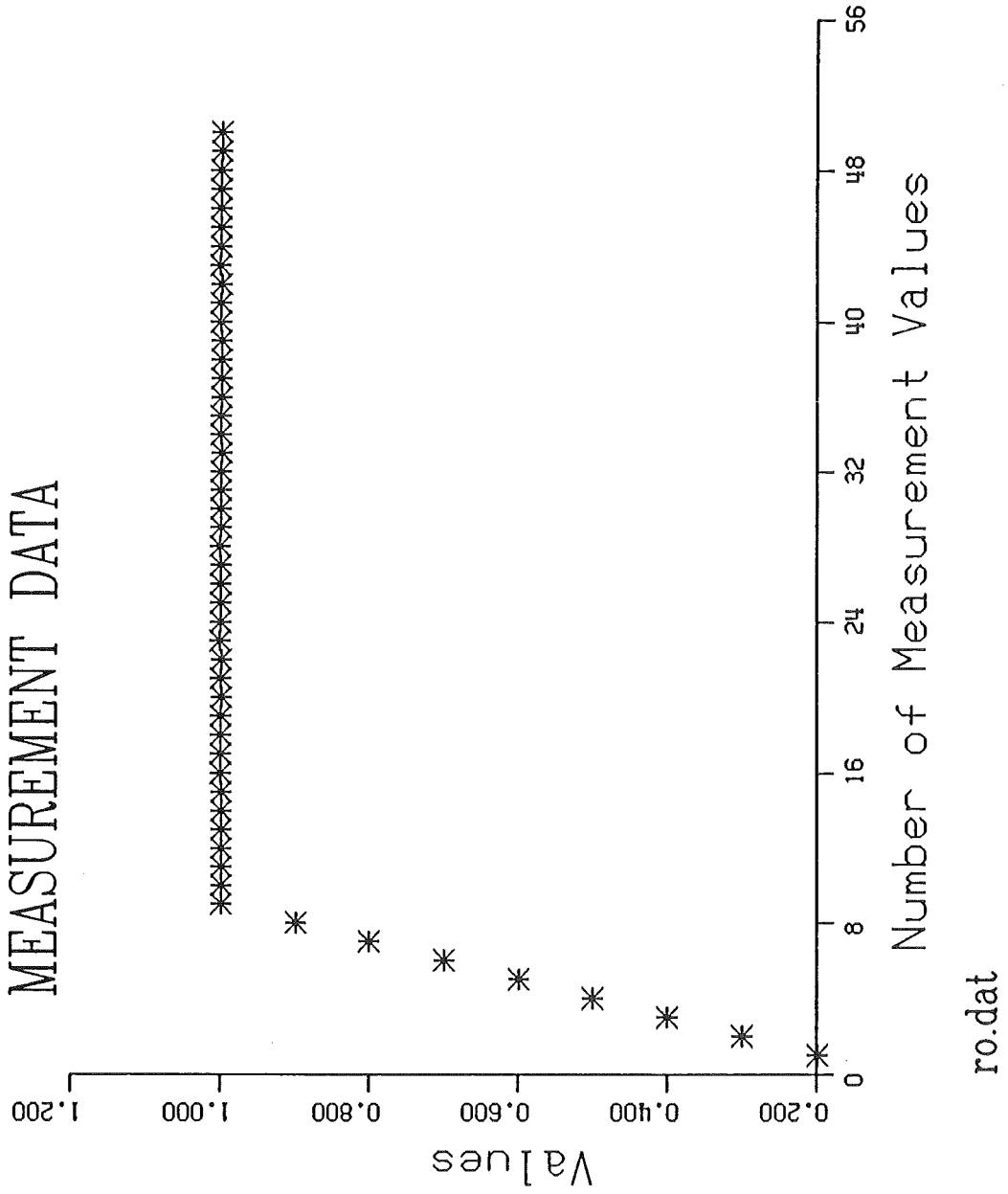
BASED ON MEAN VALUE = 0.061175

****

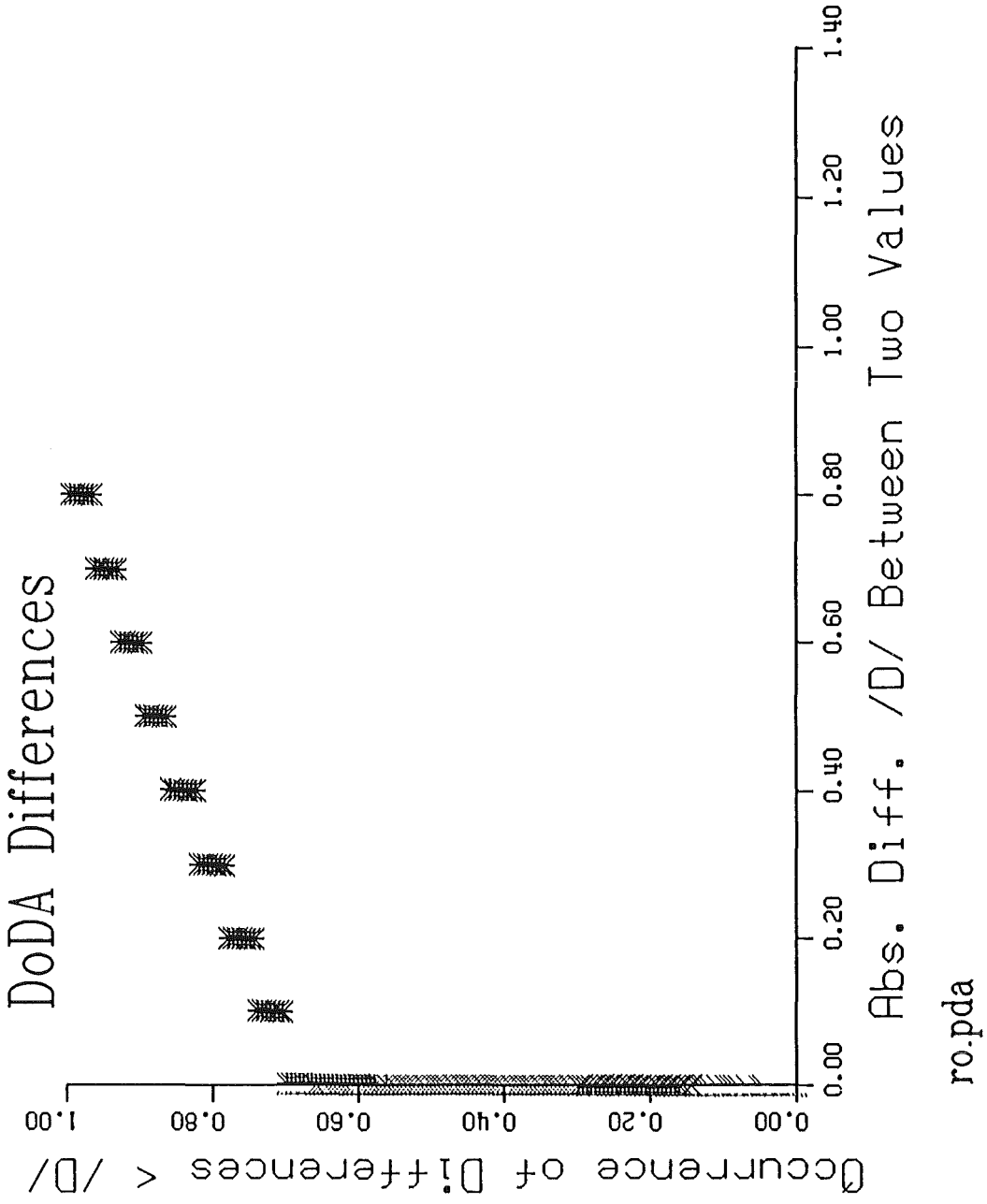
MEDIAN VALUE = 0.999500

****

9.2 Graphical Results



9. APPENDIX-I / Examples of Results



10. APPENDIX-II / Further PC-Program Packages in this Context

PC-Program Package **MEMO**

The MEMO PC program package is a tool to calculate the sequence of material balance results (MUF values) from single measurements and the related measurement model (variance/covariance matrix COVA) from the single measurement values, the measurement uncertainties and the related propagation of variances. MUF values and related variance/covariance matrix COVA are essential input parameters for materials balance evaluation programs like PROSA. MEMO Version 2.0 is a menu-guided computer program and, therefore, it is very user-friendly and is applicable in real field use. MEMO Version 2.0 is applicable whenever the amount of material in an inventory component or in a transfer batch is the result of a single measurement or the product of two measurements. The propagation of variances can be performed through the systematic error component as well as through the random error component. MEMO Version 2.0 has the capability to determine MUF and COVA sequentially. This provides a very fast determination in real field use.
For more information see "MEMO VERSION 2.0 Manual", U. Bicking, W. Golly, R. Seifert, KfK report, to be published.

PC-Program Package **PROSA**

The PROSA PC program package is a statistical tool to decide on the basis of statistical assumptions whether in a given sequence of material balance periods a loss of material might have occurred. The evaluation of the material balance data is based on statistical test procedures. In the present PROSA Version 4.0 the three tests CUMUF test, PAGE's test and GEMUF test are applied to a sequence of material balances. PROSA Version 4.0 supports a real sequential evaluation. That means, PROSA is not only able to evaluate a series of MUF values sequentially after the campaign has finished, but also real sequentially during the campaign. PROSA Version 4.0 is a menu-guided computer program and, therefore, it is very user-friendly and is applicable in real field use. Data input can be performed either by diskette or by key-enter. Result output is primarily an information whether or not an alarm is indicated. This information can be displayed either numerically or graphically. Therefore, a comfortable graphical output utility is attached to PROSA 4.0. PROSA Version 4.0 is a real-sequential program. That means, PROSA is not only able to evaluate a series of MUF values sequentially after the compaign has finished, but also real sequential during the campaign.

10. APPENDIX-II / Further Programs

For more information see "PROSA VERSION 4.0 Manual", U. Bicking, W. Golly, N. Peter, R. Seifert, KfK report 4866, May 1991.

PC-Program Package **MOCASIN**

The MOCASIN PC program package is a statistical tool to determine the detection probabilites of underlied loss-patterns using Monte-Carlo simulations. Input of MOCASIN is the measurement model (variance/covariance matrix) of a facility and an underlied loss-pattern. Output are the detection probablities of the three statistical test procedures included in MOCASIN, namely CUMUF test, PAGE's test and GEMUF test. MOCASIN 4.0 is a menu-guided computer program and, therefore, it is very user-friendly and is applicable in real field use.
The program package and a manual will be available before long.