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DIRECTORATE OF OPERATIONAL RESEARCH (JOINT)

DOR(JOINT) RESEARCH NOTE RN 2002/04

CONVERSION OF THE SLICE RANKING PROGRAM FROM FORTRAN TO MS VISUAL BASIC

By

Debbie MacLean
Rafal Lawrukiewicz

OCTOBER 2002

OTTAWA, CANADA

National Defence / Défense nationale

OPERATIONAL RESEARCH DIVISION

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Debbie MacLean
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Recommended by: _____
D.R. Hales
SPORT/TL

Approved by: _____
R.G. Dickinson
DOR(Joint)

OTTAWA, ONTARIO OCTOBER 2002

ABSTRACT

The Slice ranking algorithm, created by E.J. Emond and D.W. Mason from the Central Operational Research Team (CORT), was implemented as a software application (Slice v1.0) using the Fortran programming language. Problems encountered connecting Slice v1.0 to the Fundamental Investigation of Defence Objectives (FIDO) web-based application confirmed the need for a web compatible Slice software application. This report documents the development of Slice v2.0, a Microsoft Visual Basic program with a Fortran dynamically linked library.

TABLE OF CONTENTS

LIST OF FIGURES

CONVERSION OF THE SLICE RANKING PROGRAM FROM FORTRAN TO MS VISUAL BASIC

I. INTRODUCTION

BACKGROUND

1. In June 2000, E.J. Emond and D.W. Mason from the Central Operational Research Team (CORT) introduced a new branch and bound ranking algorithm (BB3) and heuristic (Slice) for solving consensus ranking problems. The goal of a consensus ranking problem is to determine the group ranking that is in closest agreement with a set of individual input rankings. Emond and Mason's methodology is based on their development of a new rank correlation coefficient: *tau-x*. In (References 1 and 2) *tau-x* is shown to be an effective measure of agreement that handles ties, weights and incomplete rankings in a logical manner.

2. The Slice and BB3 algorithms are both computationally intensive. Their respective software applications were developed using Fortran. This programming language was chosen in light of its ability to perform computations quickly and efficiency. The resulting Slice and BB3 software applications are DOS-prompt executables.

3. In the fall of 2000 the Strategic Planning Operational Research Team (SPORT) developed Fundamental Investigation of Defence Objectives (FIDO), a new decision support tool that interacts with the Slice ranking application. FIDO was designed to aid decision makers in understanding and resolving multi-criteria, multi-participant problems. The first version of FIDO used a Microsoft Excel implemented graphical user interface. A comprehensive discussion of FIDO v1.0 and the FIDO process in general is given in (Reference 3). A detailed user guide for FIDO v1.0 is given in (Reference 4).

4. While FIDO v1.0 was employed successfully in many sessions within the Department of National Defence (DND), it remained essentially a prototype with built-in inflexibilities and minimal error-handling/troubleshooting. The increase in demand and exposure of the FIDO tool within DND and internationally (through The Technical Co-

operation Panel (TTCP) forum) warranted the development of a flexible and robust FIDO v2.0. Starting in the fall of 2001 there were two development attempts; the first using Microsoft Access and Visual Basic and the second Microsoft Excel and flat files. In both instances the intent was to interface with the Slice ranking software. Due to problems with rapid prototyping, neither of these attempts developed into a reliable software application. The development of these two versions is documented in (Reference 5).

5. In January 2002 a contract was let to an external contractor to develop FIDO v3.0 as a web-based application connected to a database for data storage and retrieval. The development of the web version is still in progress. FIDO v3.0 will automate the interaction with Slice v1.0, despite the variety of problems encountered connecting the DOS-prompt executable during its development.

6. The first hurdle related to the actual connection of the FIDO web front end and database to the Slice ranking software. A lot of time and effort was spent to make the web and database software interoperable with the DOS-prompt executable. The second challenge arose from Slice's inability to handle multiple, simultaneous hits. Two or more parallel FIDO v3.0 sessions will result in a noticeable decrease in performance when more than one user is calculating a consensus ranking. The Vice Chief of Defence Staff Chief Information Officer (VCDS CIO) noted the third problem. Slice's DOS-prompt executable compromised the internal security of the VCDS CIO intranet server by invoking operating system commands every time the executable was run. VCDS CIO staff worked diligently to create a work-around to allow the application to be run on their web server within security regulations.

7. In May 2002, SPORT's Defence Research Assistant (DRA) Rafal Lawrukiewicz was tasked to create a new version of the Slice ranking software (Slice v2.0). The goal was to create a Slice software application that was compatible with web-related applications and met VCDS CIO security regulations, yet maintained the performance of the original Fortran version.

AIM AND SCOPE

8. The aim of this report is to document the development of Slice v2.0. The choice of converting the Slice software from Fortran to Microsoft Visual Basic (MS VB) with a Fortran dynamically linked library (DLL) is explained. A stand-alone version of Slice v2.0 is also introduced, and a brief user-guide is given. It is assumed the reader is familiar with the Slice ranking algorithm (References 1 and 2).

II. SLICE V2.0 DEVELOPMENT

CONVERSION TO MICROSOFT VISUAL BASIC

9. The initial conversion plan involved a straight translation from Fortran to MS VB. This solution ensured that the Slice algorithm logic was preserved and that a final deliverable could be produced during the DRA's work term. Both Fortran and MS VB were new programming languages for the DRA. Annex A lists internet sites found to be very useful while learning these two languages.

10. Not far into the conversion process it became obvious that the performance of a MS VB version would be unacceptable. In the early stages of coding, the computation was so intense that the processor seized and failed to respond. At this point the translation effort was suspended and two options to improve the MS VB program's efficiency were examined.

11. One particular part of the Fortran code is extremely computationally intensive. This is the 'Branch and Bound' part of the code that is executed repeatedly for each eleven option 'slice' of the potential solution ranking. It contains nine identical subroutines, each of which invokes the next subroutine twice within a loop that iterates variably depending on the input. The first attempt to increase the MS VB program's performance involved streamlining the code by converting the nine subroutines into one recursive function. After several tests it became clear that the performance of the recursive function was significantly inferior to that of the nine individual subroutines.

12. The second attempt involved reducing the number of consecutive subroutines in the 'Branch and Bound' code from nine to five. With respect to the Slice algorithm this translates into looking at 'slices' of seven options as opposed to eleven. The reduction in the number of subroutines did not result a large decrease in program execution time, which ultimately led to the decision to look for a different conversion method.

CONVERSION TO MICROSOFT VISUAL BASIC WITH A FORTRAN DYNAMICALLY LINKED LIBRARY

13. Research on the internet for an alternate way to convert a Fortran program into a modern application suggested a third option: creating a union between MS VB and a language known for its fast execution time. That is, coding the majority of the program in MS VB with calls to computationally intensive subroutines from a pre-compiled dynamically linked library (DLL) written in another language. Two candidates, both known for their computational performance, were suggested: C++ and Fortran.

14. This conversion method was chosen. Initially the C++ language was considered because it is a more modern and interoperable language in comparison to Fortran. However, Fortran was chosen in the end due to its superior performance over C++ and the fact that some of the code from Slice v1.0 could be modified and reused to speed up the development process. The creation of a Fortran DLL was possible because of the existence of language features supporting MS VB dynamic library creation in the upgraded Fortran 95 Pro v5.7 software.

15. The 'Branch and Bound' portion of the original code and other supporting functions were placed in a pre-compiled Fortran DLL, resulting in a final deliverable with performance statistics comparable to those of Slice v1.0. For example, for a sample input file of 15 options and 15 rankings the execution of Slice v1.0 was complete in less than one second. For the same input file it took Slice v2.0 one second. As the size of the input file increases there is an increase in the separation between execution times of the two versions. However, within the size range of feasible FIDO sessions, the performance differences were deemed acceptable.

SLICE V2.0 GRAPHICAL USER INTERFACE

16. In addition to the Slice v2.0 MS VB/Fortran DLL executable, a stand-alone application with a graphical user interface (GUI) was created. The GUI is presented in Figure 1. It is noteworthy that the Slice v2.0 stand-alone application combined with the Fortran DLL can be used on any Windows operating system.

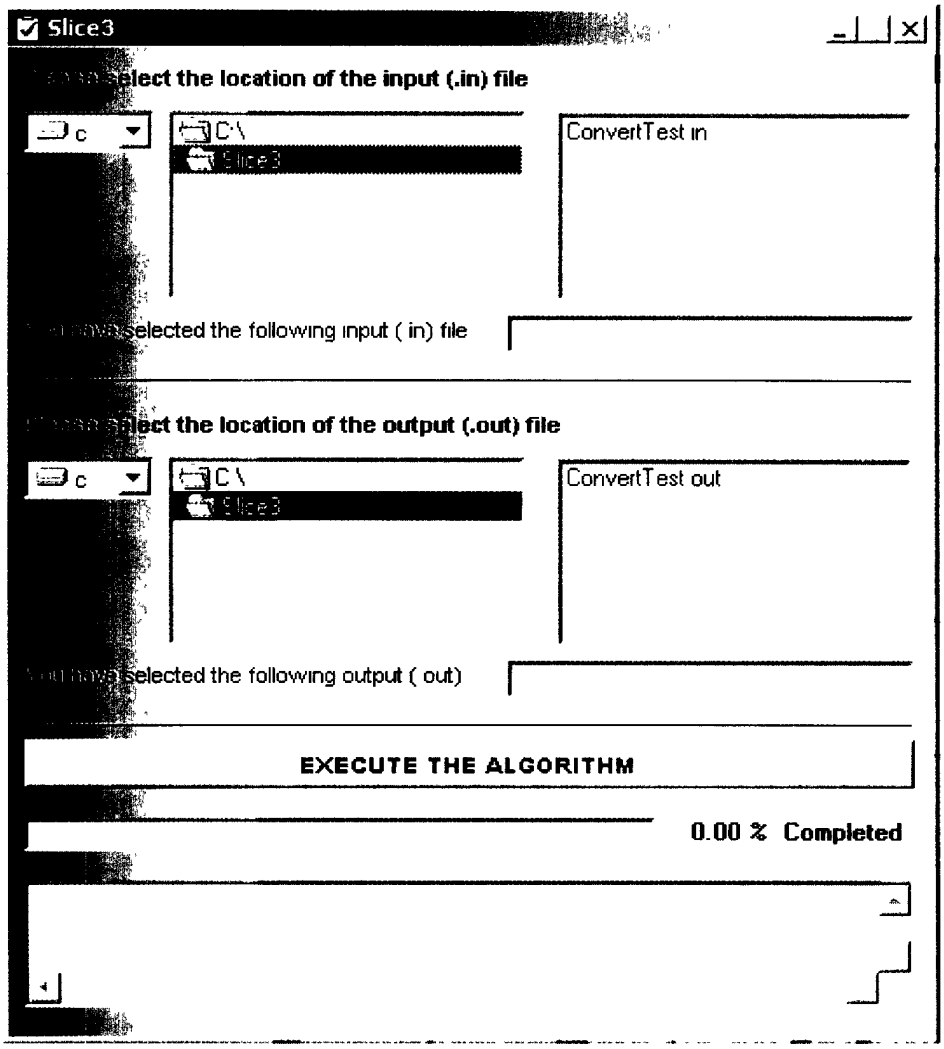

Figure 1: Slice v2.0 Graphical User Interface

17. To run Slice v2.0 through the GUI:

    a. Create an input file. A sample input file for Slice v2.0 is given in Annex B;

    b. Start the Slice v2.0 stand-alone executable (Slice.exe);

    c. Select the input file's location (drive and folder);

    d. Click on the desired input file;

    e. Select the output file's location (drive and folder);

f. Either select the desired output file or if one doesn't already exist enter an output file name in the text box located after the "You have selected the following output file (.out)" label. The file name must have the .out extension; and

g. Press the "Execute the Algorithm" button.

18. The output that was displayed to the screen in Slice v1.0 is shown in the text box located at the bottom of the GUI. The output file from the software is placed in the specified folder. A sample output file, created using the input file from Annex B, is given in Annex C.

19. The compact disk that accompanies this research note contains the code and executable for Slice v2.0. The code (front.vbp, front.frm, front.frx, front.bbw, sub3.ddl) is in the "SliceV2 Code" subfolder. The executable (Slice.exe, sub3.dll) is in the "SliceV2 Executable" subfolder. A copy of the Fortran dynamically linked library (sub3.dll) must always be kept in the same directories as the code and executable.

III. CONCLUDING REMARKS

20. Slice v2.0 could potentially replace Slice v1.0 in the FIDO web application through a follow-on contract. The MS VB/Fortran DLL Slice adaptation addresses the compatibility, multiple simultaneous users and security issues generated by Slice v1.0. For users of the Slice algorithm outside of FIDO, the Slice v2.0 GUI creates a user-friendly platform to access the software.

REFERENCES

1. A New Technique for High Level Decision Support, E.J. Emond, D.W. Mason, ORD Project Report PR 2000/13, June 2000.

2. A New Rank Correlation Coefficient with Application to the Consensus Ranking Problem, Edward J. Emond, David W. Mason, accepted for publication in the Journal of Multi-Criteria Decision Analysis.

3. Fundamental Investigation of Defence Objectives – Decision Support to the Strategic Capability Planning Process, Jason Offiong and Paul Comeau, ORD Project Report PR 2000/20, November 2000.

4. Fundamental Investigation of Defence Objectives User Guide for FIDO Version 1.0, Debbie MacLean, DOR(J&L) Research Note RN 2000/25, December 2000.

5. Development of Fundamental Investigation of Defence Objectives (FIDO) Version 2.0, Debbie MacLean, Mira Halbrohr, DOR(JOINT) Research Note RN 2001/09, November 2001.

ANNEX A
DOR(JOINT) RN 2002/04
OCTOBER 2002

USEFUL WEBSITES FOR LEARNING FORTRAN AND MS VISUAL BASIC

Fortran:

Lynn, K. (1999). CIS 227 Laboratory – June 22, 1999
http://www.cis.usouthal.edu/faculty/lynn/summer99/labs/june22fortran.html

Brettin, M. Fortran Tutorial
http://www.la.unm.edu/~mbrettin/languages/fortran_tutorial.html

Burkardt, T. (2001). FORTRAN Source Codes
http://www.psc.edu/~burkardt/src/f_src.html

Schonfelder, L. (1999). Varying Length Character Strings in Fortran
http://www.pcweb.liv.ac.uk/jls/is1539-2-99.htm

von Petersdorff, T. (1996). A Short Intoduction to Fortran 90
http://www.wam.umd.edu/~petersd/fort90intr/node1.html

Visual Basic:

Beene, G. (2001). Gary Beene's Visual Basic Information Center
http://www.vbinformation.com/tut-file.htm

Zakikian, F. Automate WordPerfect from VB (Article)
http://www.freevbcode.com/ShowCode.Asp?ID=4021

Klieger, R. String Manipulation
http://www.geocities.com/alpha_productions2/vb_stringmanip.htm

2002 Business Prof. (2002). Beginning VB Objects
http://www.listensoftware.com/vblesson3.html

Paolini, P. (1999). Computers in Biomedical Research : Visual Basic
http://www.sci.sdsu.edu/classes/bio595/VB_lesson_14.html

McGowan, F. (1998). The Errors of Our Ways
http://www.windowatch.com/vbtut5.html

Wilson, K. (2002). HOWTO Lesson 1 : Creating .EXE's
http://w3.one.net/~kevinw/VB/l_exe.htm

Saunders, G. (2002). Scripts
http://www.courses.vcu.edu/INFO258-gs/scripts.htm

Sabitov, R. (2002). Learn Visual Basic
http://rustemsoft.com/Beginner.htm

Birch, R. (2002). Adding AutoComplete to a VB Text Box
http://www.mvps.org/vbnet/index.html?code/textapi/shautocomplete.htm

Clemenzi, R. (2002). CR/LF
http://www.cpcug.org/user/clemenzi/technical/Languages/CR_LF.htm

Voon Kiong, L. (2002). Lesson 10: Introduction to VB Functions – Part 1
http://www.vbtutor.net/lesson10.html

A1VBCode. (2002). A1VBCode The VB Source Code Site
http://www.a1vbcode.com/code.asp?type=controls&intPage=1

Michael, N. (2000). Nico's VB Language Chart 1 (By Category)
http://www.companyontheweb.com/ixthis/VB1.html

Salimi, M. (2002). Visual Basic Bookmark – Source Code Archives
http://www.vb-bookmark.com/vbSourceCode.html

ANNEX B
DOR(JOINT) RN 2002/04
OCTOBER 2002

SLICE V2.0 INPUT FILE

16 Options

18 Rankings

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10	9	7	9	7	9	9	8	9	9	8	7	5	8	10	8	10
25	12	10	15	16	2	1	2	3	14	12	4	5	15	16	13	4
20	15	12	12	12	10	10	10	16	10	9	14	4	12	16	10	3
10	8	4	7	5	10	9	9	9	5	5	7	3	6	10	6	9
10	9	8	9	7	9	8	9	9	8	8	6	4	7	9	9	9
25	16	14	16	15	15	14	13	12	11	10	9	13	10	11	11	11
10	9	7	8	7	8	8	6	7	8	8	7	6	7	10	8	8
25	16	11	14	13	2	3	4	5	14	12	6	8	14	7	14	8
20	15	8	12	9	16	18	16	16	11	10	16	5	12	16	12	5
10	7	4	6	5	9	9	9	9	6	6	7	3	6	8	6	9
10	9	9	9	6	9	8	8	9	8	7	6	4	7	8	8	8
25	16	15	10	15	9	8	7	6	5	4	3	2	1	2	3	4
10	9	7	8	8	8	8	7	8	8	8	6	5	7	10	6	8
25	16	15	15	15	1	1	2	3	12	11	16	10	16	4	15	4
20	13	11	8	13	16	16	16	15	8	10	14	6	12	16	11	5
10	6	6	7	6	9	8	9	8	7	5	6	5	5	8	6	8
10	9	8	9	6	9	9	9	9	8	8	6	6	7	8	8	8
25	16	14	10	15	1	2	3	4	5	16	15	14	12	11	10	2

A Slice v2.0 input file consists of the following components:

a. The first line gives the number of options to be ranked;

b. The second line gives the total number of rankings to be submitted to the algorithm;

c. The first row of numbers is a list of numbers from 1 to the number of options;

d. The remaining rows of numbers are the rankings being submitted to the algorithm. Since there are 18 rankings in the example above, there are 18 rows of numbers beneath the first row of consecutive integers (1 to the number of options);

(1) The weights corresponding to the rankings are given in the first column. In the example, the first ranking has been assigned a weight of 10;

(2) In the second column (under the '1' from the first row) the ranking of option 1 in each of the rankings is given. In the example above, option 1 is ranked 9^{th} in the first ranking, 12^{th} in the second ranking, 15^{th} in the third ranking, and so on;

(3) In the third column (under the '2' from the first row) the ranking of option 2 in each of the rankings is given. In the example above, option 2 is ranked 7^{th} in the first ranking, 10^{th} in the second ranking, 12^{th} in the third ranking, and so on. This pattern is repeated for each of the columns (1 to the number of options);

e. Note 1: A zero rank of an option is equivalent to a non-rank/abstention;

f. Note 2: Decimal weights or rankings are not allowed; and

g. Note 3: Slice v2.0 requires a minimum of 11 options.

ANNEX C
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SLICE V2.0 OUTPUT FILE

```
Q:\SPORT\FIDO\Version 3.0\Supporting
Applications\Slice\FortrantoVBConversion\Slice3\FINAL
VERSION\ConvertTest.in

MINIMUM PENALTY FOUND =      1380

 1 )           1380
 12  11  16  10   9 -13 -15   5 -6 -7 -8   2   3 -4   1 -14
 2 )           1380
 12  11  16  10   9 -13 -15   5 -6 -7 -8   2   4   3   1 -14

 12            0   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 11           -1   0   1   1   1   1   1   1   1   1   1   1   1   1   1   1
 16            1  -1   0   1   1   1   1   1   1   1   1   1   1   1   1   1
 10           -1  -1  -1   0   1   1   1   1   1   1   1   1   1   1   1   1
 9            -1  -1  -1  -1   0   1   1   1   1   1   1   1   1   1   1   1
 13           -1   1  -1   1   1   0   1   1   1   1   1   1   1   1   1   1
 15           -1   1  -1  -1   1   1   0   1   1   1   1   1   1   1   1   1
 5            -1  -1   0  -1   0  -1  -1   0   1   1   1   1   1   1   1   1
 6            -1  -1   1  -1   1  -1   0   1   0   1   1   1   1   1   1   1
 7            -1   0  -1  -1   1   0   1   1   1   0   1   1   1   1   1   1
 8            -1  -1  -1  -1  -1  -1  -1   1   1  -1   0   1   1   1   1   1
 2            -1   1  -1   1   0   1   1   1  -1  -1   0   0   1   1   1   1
 4            -1   1  -1  -1  -1   1   0   1  -1  -1   0  -1   0   1   1   1
 3            -1  -1  -1  -1  -1   1  -1  -1  -1  -1  -1  -1   0   0   1   1
 1            -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1  -1   0   1
 14           -1  -1   1  -1  -1  -1  -1   0  -1  -1  -1  -1   0  -1   1   0

 16  Options
 18  Rankings
        12  11  16  10   9  13  15   5   6   7   8   2   4   3   1  14
 10      5   7  10   8   9   8   8   9   9   8   9   7   7   9   9  10
 25      5   4   4  12  14  15  13   2   1   2   3  10  16  15  12  16
 20      4  14   3   9  10  12  10  10  10  10  16  12  12  12  15  16
 10      3   7   9   5   5   6   6  10   9   9   9   4   5   7   8  10
 10      4   6   9   8   8   7   9   9   8   9   9   8   7   9   9   9
 25     13   9  11  10  11  10  11  15  14  13  12  14  15  16  16  11
 10      6   7   8   8   8   7   8   8   8   6   7   7   7   8   9  10
 25      8   6   8  12  14  14  14   2   3   4   5  11  13  14  16   7
 20      5  16   5  10  11  12  12  16  18  16  16   8   9  12  15  16
 10      3   7   9   6   6   6   6   9   9   9   9   4   5   6   7   8
 10      4   6   8   7   8   7   8   9   8   8   9   9   6   9   9   8
 25      2   3   4   4   5   1   3   9   8   7   6  15  15  10  16   2
 10      5   6   8   8   8   7   6   8   8   7   8   7   8   8   9  10
 25     10  16   4  11  12  16  15   1   1   2   3  15  15  15  16   4
 20      6  14   5  10   8  12  11  16  16  16  15  11  13   8  13  16
 10      5   6   8   5   7   5   6   9   8   9   8   6   6   7   6   8
 10      6   6   8   8   8   7   8   9   9   9   9   8   6   9   9   8
```

```
 25      14  15  2  16  5  12  10  1  2  3  4  14  15  10  16  11
1380

Ranking  Weight   Correlation
   1        10     0.2917
   2        25     0.2250
   3        20     0.5250
   4        10     0.2833
   5        10     0.3583
   6        25     0.5417
   7        10     0.2833
   8        25     0.1583
   9        20     0.3000
   10        10     0.1583
   11        10     0.4750
   12        25     0.5500
   13        10     0.4833
   14        25     0.0417
   15        20     0.3417
   16        10     0.2417
   17        10     0.4083
   18        25     0.0250

Weighted Avg. Corr. = 0.3057
```

A Slice v2.0 output file consists of the following components:

a. The first line gives the name of the input file fed into Slice v2.0 to create the output file;

b. The second line states the minimum penalty. In the example 1380 was the minimum penalty found;

c. The next part of the output file lists the solutions. Sometimes it first lists solutions with penalties higher then the minimum penalty. In the example only two solutions with the minimum penalty are given;

d. For each solution:

(1) On the first line the solution number and penalty associated with that solution is given;

(2) On the second line the solution is given. From the example output file solution 1) is interpreted as follows: Option 12 is ranked 1st, option 11 is 2nd, option 16 is 3rd and option 10 is 4th. Options 9, 13 and 15 are tied for 5th due to the minus signs between them. When

an option has a minus sign in front of it, it is tied with the option listed in front of it.

e. The remainder of the output file consists of a ranking matrix for the solutions, an alternative format for the input file, a table of input ranking correlation coefficients and the weighted average correlation coefficient respectively.

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The Slice ranking algorithm, created by E.J. Emond and D.W. Mason from the Central Operational Research Team (CORT), was implemented as a software application (Slice v1.0) using the Fortran programming language. Problems encountered connecting Slice v1.0 to the Fundamental Investigation of Defence Objectives (FIDO) web-based application confirmed the need for a web compatible Slice software application. This report documents the development of Slice v2.0, a Microsoft Visual Basic program with a Fortran dynamically linked library.

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Slice Ranking Algorithm
Tau-X
Fundamental Investigation of Defence Objectives (FIDO)
Fortran
Microsoft Visual Basic
Dynamically Linked Library (DLL)

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