

SOFTWARE RELEASE NOTICE

1. SRN Number: PA-SRN-242		
2. Project Title: General Use		Project No. General use
3. SRN Title: Crystal Ball 2000 V.5.1		
4. Originator/Requestor: James Weldy		Date: 4/26/2001
5. Summary of Actions <input checked="" type="checkbox"/> Release of new software <input type="checkbox"/> Release of modified software: <input type="checkbox"/> Enhancements made <input type="checkbox"/> Corrections made <input type="checkbox"/> Change of access software <input type="checkbox"/> Software Retirement		
6. Persons Authorized Access		
Name	Read Only/Read-Write	Addition/Change/Delete
All, but license limited to installation on one machine	RW	Addition
7. Element Manager Approval: Gordon Wittmeyer <i>Gordon Wittmeyer</i>		Date: 4/27/2001
8. Remarks:		

SOFTWARE SUMMARY FORM

01. Summary Date: 4/27/2001	02. Summary prepared by (Name and phone) James Weldy (210.522.6800)	03. Summary Action: N/A	
04. Software Date: 1988-2000 (copyright)	05. Short Title: Crystal Ball 2000 V.5.1		
06. Software Title: Crystal Ball 2000 V.5.1		07. Internal Software ID: N/A	
08. Software Type: <input type="checkbox"/> Automated Data System <input checked="" type="checkbox"/> Computer Program <input type="checkbox"/> Subroutine/Module	09. Processing Mode: <input checked="" type="checkbox"/> Interactive <input type="checkbox"/> Batch <input type="checkbox"/> Combination	10. APPLICATION AREA a. General: <input checked="" type="checkbox"/> Scientific/Engineering <input type="checkbox"/> Auxiliary Analyses <input type="checkbox"/> Total System PA <input type="checkbox"/> Subsystem PA <input type="checkbox"/> Other b. Specific:	
11. Submitting Organization and Address: Decisioneering 1515 Asapanoe St, Suite 1311 Denver, CO 80202		12. Technical Contact(s) and Phone: Decisioneering (303.534.1515)	
13. Software Application: Works with the Microsoft Excel program to provide probabilistic sampling capabilities to Excel spreadsheets.			
14. Computer Platform Windows NT	15. Computer Operating System: Windows NT	16. Programming Language(s): N/A	17. Number of Source Program Statements: Acquired code
18. Computer Memory Requirements: minimum 586	19. Tape Drives: N/A	20. Disk/Drum Units: N/A	21. Graphics: available
22. Other Operational Requirements: N/A			
23. Software Availability: <input checked="" type="checkbox"/> Available <input type="checkbox"/> Limited <input type="checkbox"/> In-House ONLY		24. Documentation Availability: <input checked="" type="checkbox"/> Available <input type="checkbox"/> Inadequate <input type="checkbox"/> In-House ONLY	
Software Developer: Decisioneering Date: 4/27/2001			

James K. Weldy

**CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES
DESIGN VERIFICATION REPORT FOR CNWRA SOFTWARE**

ACQUIRED CODE - NOT TO BE MODIFIED¹

Software Title/Name: Crystal Ball 2000
Version: 5.1
Demonstration workstation: Kraken
Operating System: Windows NT
Developer: Decisioneering

1. Output: TOP-018, Section 5.5.4

Software designed so that individual runs are uniquely identified by Date, Time, Name of software and version?

Yes: ☐ No: ☐ N/A: ☒

Date and time of run: _____

Name and version: _____

Notes: Acquired code that is not to be modified is accepted as is.

2. Medium and Header Documentation: TOP-018, Section 5.5.6

The physical labeling of software medium (tapes, disks, etc.) contain required information?

Yes: ☐ No: ☐ N/A: ☐

Program Name: Crystal Ball 2000 Version 5.1
Module/Name/Title: " " " " "
Module Revision: " " " " "
File Type (ASCII, OBJ, EXE): EXE
Recording Date: by H-STREET AT CNWRA - 4/25/2001
Operating System of Supporting Hardware: Windows NT/PC

Notes: Acquired code that is not to be modified may not have all above elements.

¹ See TOP-018, Table 1 for criteria.

**DESIGN VERIFICATION REPORT FOR CNWRA SOFTWARE
ACQUIRED CODE - NOT TO BE MODIFIED**

3. User's Manual: TOP-018, Section 5.5.5

- a) Is there a Users' Manual for the software?

Yes: ☒ No: ☐ N/A: ☐

User's Manual Version and Date: Copyright 1988-2000

Notes:

- b) Are there basic instructions for the use of the software?

Yes: ☒ No: ☐ N/A: ☐

Location of Instruction: Office A-206 (James Weldy)

Notes:

4. Acceptance Testing: TOP-018, Section 5.6

- a) Has installation testing been conducted for each intended computer platform and operating system?

Yes: ☒ No: ☐ N/A: ☐

Platform(s): PC - "Kraken" Room A-206 - J. Weldy

Operating System(s): Windows NT

Location of Test Results: QA Records Room

Notes:

5. Configuration Control: TOP-018, Section 5.7

- a) Is the Software Summary Form completed and signed?

Yes: ☒ No: ☐ N/A: ☐

Software Summary Form Approval Date: 4/27/2001

Notes:

- b) Is a software technical description prepared, documenting the essential mathematical and numerical basis?

Yes: ☒ No: ☐ N/A: ☐

Location Technical Description: Located in users manual

Notes:

- c) Is the source code available (or, is the executable code available in the case of (acquired/commercial codes)?

Yes: ☒ No: ☐ N/A: ☐

Location of Source Code: On Kraken, copies in the QA records room.
Executable only.

Notes:

**DESIGN VERIFICATION REPORT FOR CNWRA SOFTWARE
ACQUIRED CODE - NOT TO BE MODIFIED**

6. Configuration Control, continued: TOP-018, Section 5.7

Have all the script/make files and executable files been submitted to the Software Custodian?

Yes: ☒ No: ☐ N/A: ☐

Location of Script/Make Files: QA records room

Notes:

7. Software Release: TOP-018, Section 5.9

Upon acceptance of the software as verified above, has a Software release Notice, Form TOP-6 been issued?

Yes: ☒ No: ☐ N/A: ☐

Version number on software (1.0 for 1st issue): 5.1

Version number on SRN: 5.1

Notes: SEE SRD Number PA-SRN-242

8. Software Validation: TOP-018, Section 5.10

a) Has a Software Validation Test Plan (SVTP) been prepared for the range of application of the software?

Yes: ☐ No: ☒ N/A: ☒

Version/Date of SVTP: _____

Date reviewed and approved via QAP-002: _____

Notes:

b) Has a Software Validation Test Report (SVTR) been prepared that documents the results of the validation cases, interpretation of the results, and determination if the software has been validated?

Yes: ☐ No: ☒ N/A: ☒

Version/Date of SVTR: _____

Date reviewed and approved via QAP-002: _____

Notes:

Additional Remarks:

James R. Welch
CNWRA Software Developer/Date

Bruce Mahub 4/27/2001
CNWRA Software Custodian/Date

Subject: RE: Crystal Ball

Date: Tue, 24 Apr 2001 11:03:53 -0500

From: James Weldy <jweldy@swri.edu>

To: "Bruce Mabrito (bmabrito)" <bmabrito@swri.edu>

Sorry, noticed a typo in the file. Attached is the correct file.

James

-----Original Message-----

From: James Weldy [mailto:jweldy@gargol.cnwra.swri.edu]

Sent: Tuesday, April 24, 2001 10:35 AM

To: Bruce Mabrito (bmabrito)

Subject: Crystal Ball

Bruce,

I would like to place the Crystal Ball software package under TOP-18 Configuration Control. It is acquired software which will not be modified. I have performed the installation testing and will provide you with the documentation from Scientific Notebook # 419 and a printout of the computer files used to run the tests. The computer files from the installation testing are also attached to this email. Hollen should have provided you with a copy of the software. Let me know if you need anything else.

Thanks,

James Weldy



QACBcheck.xls

Name: QACBcheck.xls

Type: Microsoft Excel Worksheet (application/vnd.ms-excel)

Encoding: base64

Testing occurred on the computer, Kraken in room A206 of
Building 189 of The CNWRA.

James H. Weldy

	Min	Mean (TPA 4.0 User's Guide Calc)	Variance (TPA 4.0 User's Guide Calc)	Peak or alpha	beta or lambda	Max	CB definition	CB Mean	CB Results (Mean)	CB Results (Median)	CB Results (Variance)	% Difference between CB and TPA 4.0
	1	5.5	6.75			10	5.5	5.5	5.499	8.28	6.7595	-0.00010037
Log-uniform	1	3.944037591	6.9288143			10	0.5	3.162278	3.902	5.67	6.1925	-0.01060881
Normal	1	5.5	2.120521676			10	5.5	5.5	5.498	4.42	2.1200	-0.00043276
Log-normal	1	3.389534119	1.710636237			10	3.2	3.2	3.392	2.70	1.7182	0.0008259
Triangular	1	5.333333333	3.388888889	5		10	5	5	5.336	7.53	3.3831	0.00041377
Beta	0	0.285714286	0.025510204	2	5	1	0.3	0.3	0.286	0.17	0.0254	0.00030197
Exponential		100	10000		0.01		100	100	100.172	105.99	10031.5283	0.00172408
Weibull (Location parameter in min column)	2	7.999999999	13.41640786	3	0.5		1	1	7.980	3.58	13.3100	-0.0025
			1.151292546	0.37256								
			1.151292546	0.6647								

Crystal Ball V 5.1
TEST CASE

Statistics	CB Mean	I3	I4	I5	I6	I7	I8	I9
Trials	333560	333560	333560	333560	333560	333560	333560	333560
Mean	5.50	3.90	5.50	3.39	5.34	0.29	100.17	7.98
Median	8.28	5.67	4.42	2.70	7.53	0.17	105.99	3.58
Mode	---	---	---	---	---	---	---	---
Standard Deviation	2.60	2.49	1.46	1.31	1.84	0.16	100.16	13.31
Variance	6.76	6.19	2.12	1.72	3.38	0.03	10,031.53	177.24
Skewness	0.00	0.77	0.01	1.22	0.11	0.60	1.97	6.67
Kurtosis	1.80	2.46	2.99	5.82	2.40	2.89	8.63	87.44
Coeff. of Variability	0.47	0.64	0.26	0.39	0.34	0.56	1.00	1.67
Range Minimum	1.00	1.00	0.00	0.51	1.00	0.00	0.00	2.00
Range Maximum	10.00	10.00	12.40	20.32	9.97	0.95	1,105.97	515.47
Range Width	9.00	9.00	12.39	19.80	8.97	0.95	1,105.97	513.47
Mean Std. Error	0.0045	0.0043	0.0025	0.0023	0.0032	0.0003	0.1734	0.0231

11-2-00

SLW

Check on the Crystal Ball software

Crystal Ball is a commercial software package that was used to allow Microsoft Excel to probabilistically sample values in its cells. This package was used by SAIC for their Monte Carlo analysis of the results. A check was performed to ensure that the Crystal Ball software properly calculates the mean and variance of some of the most commonly used distributions.

The distributions that were checked included the uniform, normal, log-normal, triangular, beta, and exponential distributions. After 500,000 realizations, the following results were obtained: (note that the CB results were compared to the formulae to calculate the means and variances from various distributions in the TPA 4.0 User's Guide (Muhaly et al., 2000). The results are in the file QACBcheck.xls.

Distribution	Parameters	Mean-calc	Mean-CB	Variance-calc	Variance-CB
Uniform	(1,10) (min, max)	5.5	5.50	6.75	6.74
Log-normal Normal	(1,10) ^{0.1%, 99.9%} (min, max)	5.5	5.50	2.12	2.12
* Log-normal	(1,10) (0.1%, 99.9%)	3.39	3.39	1.71	1.71
Triangular	(1,5,10) (min, peak, max)	5.33	5.34	3.39	3.38
Beta	(0.1, 2.5) (min, max, alpha, beta)	0.286	0.286	0.0255	0.0356
Exponential	0.01 (lambda)	100	100.05	10000	10029
Weibull	(2, 3, 0.5) (location, scale, shape)	8.0	7.98	13.42	13.31

- This is exceptional agreement, so there is confidence that Crystal Ball is performing correctly.

* Note that the formulae for the mean and variance for a log-normal distribution are not specified in the User's Guide. These formulae are:

$$\text{mean} = e^{u + \sigma^2/2}$$

$$\text{variance} = (e^{2u + 2\sigma^2}) (e^{\sigma^2} - 1)$$

where u and σ are the mean and variance of the log-transformed distribution calculated using the standard formulae for a normal distribution

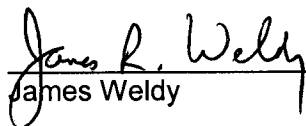
- Mean and variance of the Weibull distribution are from McCormick, 1981 - Reliability and Risk Analysis

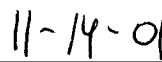
**SOFTWARE VALIDATION TEST PLAN FOR CRYSTAL BALL 2000
VERSION 5.1**

November 8, 2001

Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute
San Antonio, Texas

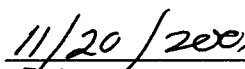
Author


James Weldy


Date

Element Manager


Gordon Wittmeyer


Date

1 SCOPE OF THE VALIDATION

Crystal Ball 2000 Version 5.1 (Decisioneering, 2000) is an acquired software not to be modified and is under configuration control at the Center for Nuclear Waste Regulatory Analyses (CNWRA), software release number 242. Crystal Ball 2000 Version 5.1 was developed by Decisioneering for commercial use. All references to Crystal Ball in this plan refer to Crystal Ball 2000 Version 5.1.

The validation test covers the ability of the Crystal Ball code to sample from probability distribution functions and calculate the mean and variance of the resulting distribution. This validation will not cover other tools within the Crystal Ball package, including the Batch Fit tool, the Bootstrap tool, the Correlation Matrix tool, the Decision Table tool, the Tornado Chart tool, or the Two-dimensional Simulation tool, because these functions are not expected to be used in licensing work.

2 REFERENCES

Abramowitz, M. and I. Stegun. "Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables." New York, New York: Dover Publications, Inc. 1972.

Decisioneering. "Crystal Ball 2000 User Manual." Denver, Colorado: Decisioneering. 2000.

Kelton, W.D. and Law, A.M. "Simulation Modeling and Analysis." New York, New York: McGraw-Hill, Inc. 1991.

McCormick, N.J. "Reliability and Risk Analysis: Methods and Nuclear Power Applications." Boston, Massachusetts: Academic Press, Inc. 1981.

McLaughlin, M. "Regress+ User's Guide. Appendix A: A Compendium of Common Probability Distributions." McLean, Virginia: Michael A. McLaughlin. 1999.

3 ENVIRONMENT

3.1 Software

Crystal Ball is Windows ®-based and runs under Windows 95, Windows 98, Windows 2000, or Windows NT 4.0 Operating Systems. The validation test will be conducted under a Windows NT Version 4.0 operating system. Crystal Ball requires Microsoft Excel 95 (or later) to be installed on the machine that it is running on. The following list of files are required for the test.

- Input file
 - QACBcheck.xls
- Executable files
 - CB.xla
 - excel.exe
- Solution file
 - QACBcheck.xls

The Crystal Ball Software samples from probability distribution functions using either Monte Carlo or Latin hypercube sampling. Monte Carlo Sampling is sampling in which the random numbers generated are totally independent of one another. Latin hypercube sampling is conducted by dividing the probability distribution function into a number of equally probable bins and selecting an equal number of samples from each of these bins. The Multiplicative Congruential generator routine (Kelton and Law, 1991) is used to generate random numbers for the sampling routines.

3.2 Hardware

The required hardware is an IBM-compatible personal computer with a CD-ROM drive, at least 16 MB of RAM, a hard-disk drive with at least 16 MB free, a VGA or SVGA graphics card or compatible video graphics adapter, and a monitor.

4 PREREQUISITES

None

5 ASSUMPTIONS AND CONSTRAINTS

None.

6 TEST CASE

6.1 Parameter Sampling Test

This test involves using the Crystal Ball software to sample from each of the probability distribution functions that the software is capable of sampling. The results of the sampling conducted by the Crystal Ball software will be tabulated in a Forecast window. This will include the calculation of the mean and variance of the distribution that results from the sampling. The mean and variance of the resulting distribution will be compared to the mean and variance of the sampled distribution. The comparison will be done using formulae available in reference textbooks, such as McCormick (1981), McLaughlin (1999), or Abramowitz and Stegun (1972). Validation will be performed for both the Monte Carlo and Latin hypercube sampling routines, and the number of realizations needed for the software to return acceptable results for each sampling routine will be documented.

6.2 Test Input

The files required for the test are listed in Section 3.1, Software.

6.3 Test Procedure

The steps of the test procedure are listed below.

Step 1: Load the file QACBcheck.xls.

Step 2: Clear any previous results by clicking on "Reset" under the "Run" menu.

- Step 3: Set number of realizations to the desired number by clicking on "Run Preferences" under the "Run" menu, changing the number of realizations to the desired number, and clicking on "OK."
- Step 4: Execute the Crystal Ball program by clicking on "Run" under the "Run" menu.
- Step 5: Extract results by clicking on "Extract Data" under the "Run" menu, then selecting "Statistics" and clicking on "OK."
- Step 6: Compare resulting mean and variance of the distribution with those calculated using formulae from reference textbooks.

6.4 Expected Test Results

The test procedure produces a table of the statistics (including the mean and the variance) of the distributions available in the Crystal Ball software package. These results should be consistent specified mean and the variance. Because means and variances of finite populations are just estimators of true means and variances, it is expected that there will be variation between the Crystal Ball results and the true means and variances (the test cannot run an infinite number of realizations). Therefore, the results are considered acceptable if the mean predicted by Crystal Ball matches the hand calculations within $\pm 5\%$, and the variance predicted by Crystal Ball matches the hand calculations within $\pm 5\%$.