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Report Recipient:	Nolimit City Limited Ajiree Court, Suite 1C, Testaferrata Street Ta' Xbiex, XBX1402 Malta
Jurisdiction:	Curacao Online
Technical Standards for Testing:	GLI-11 Gaming Devices in Casinos V1.3
Software Supplier:	Nolimit City Limited Ajiree Court, Suite 1C, Testaferrata Street Ta' Xbiex, XBX1402 Malta
Submitting Party/ Licensee Name:	Nolimit City Limited Ajiree Court, Suite 1C, Testaferrata Street Ta' Xbiex, XBX1402 Malta
Product Tested:	**Fortuna Random Number Generator (RNG)**
Evaluation Period:	22nd September 2016 / 31st October 2016
File Number:	RN-246-NOC-16-01
Testing Result:	Subject to the Conditions of Evaluation (page 10) : **Complies**

Software Product Details

GLI tested Nolimit City Limited's "Fortuna Random Number Generator (RNG)" for use within the jurisdiction of Curacao Online, as regulated by the Curacao Gaming Control Board.

For version-control of the files, GLI gathered the following checksums:

File Name	MD5 Signature	SHA-1 Signature
RandomProvider-1.0.jar	E177D742 3160283F 74D5E62F 8C5268BB	C8822807 AA450C80 11ECC25C C9A16441 D86C4042
fortuna-1.0.jar	158136DB 33D1E0BB 8A332EAE EC9CB106	BB72B47E 979F8379 227201BB F57B9CFB A4C35E2E
AuditService-1.0.jar	7876C14F 7A828B82 6F34FB05 D5738004	F58A2C63 951A25DA AD6D0C91 5DD4F38E 944A64DA
XORShift64Star.class	608DAC0A 22C0EBFB A3BA30BC BE4F410B	E4145FF3 DB7F5F34 A99BC5BD 91E9D261 771E73F3
XORShiftBase.class	DD044C60 414FE7C9 3A4D06C1 9E0FDA58	2C7EA6FB B8C32FBC 8F9DF897 B8BFA4A0 0C425E52

RNG Evaluation

GLI's RNG Evaluation included (but was not necessarily limited to) the following elements:

- General RNG Analysis,
  - Submitted Documentation Review,
  - Source Code Read,
  - Review of Test Results,
  - Jurisdictional Review of RNG Design,
  - Data Generation,
  - Data Analysis,
- Final Outcome Distribution Tests.

RNG Evaluation

RANDOMNESS REPORT FOR THE FORTUNA RNG

The intent of this report is to indicate that **Gaming Laboratories International**, **LLC** (GLI) has completed its evaluation of the "Fortuna Random Number Generator (RNG)" provided by Nolimit City Limited.

SECTION I — SCOPE OF TESTING

Nolimit City Limited submitted the required materials to GLI in order to conduct a random number generator analysis on the Fortuna RNG. The scope of this analysis was limited to software verification, source code review, and data analysis. The RNG was tested for its ability to randomly produce outcomes for the "Oktoberfest" game.

SECTION II — SOFTWARE VERIFICATION

Verify+ by Kobetron™ signatures for the Fortuna RNG are as follows:

File	Version	Type	Signature
RandomProvider-1.0.jar	1.0	SHA-1	C8822807 AA450C80 11ECC25C C9A16441 D86C4042
fortuna-1.0.jar	1.0	SHA-1	BB72B47E 979F8379 227201BB F57B9CFB A4C35E2E
AuditService-1.0.jar	1.0	SHA-1	F58A2C63 951A25DA AD6D0C91 5DD4F38E 944A64DA
XORShift64Star.class	N/A	SHA-1	E4145FF3 DB7F5F34 A99BC5BD 91E9D261 771E73F3
XORShiftBase.class	N/A	SHA-1	2C7EA6FB B8C32FBC 8F9DF897 B8BFA4A0 0C425E52

Table 1. Digital Signatures

RNG Evaluation

SECTION III — SOURCE CODE REVIEW

Nolimit City Limited submitted appropriate documentation and full source code which pertains to the generation of random numbers. GLI reviewed the source code provided by tracing the path of the RNG application from the initiation of the draw to the selected output of random numbers. GLI inspected the source code, where practicable, in an attempt to find any undisclosed switches or parameters having a possible influence on randomness and fair play. GLI assessed the ability of the RNG to produce all numbers within the desired range.

SECTION IV — DATA ANALYSIS

The game configuration and parameters for the data obtained and tested are listed in Table 2.
GLI performed a data format check on each data set listed in order to confirm that the game parameters were correctly represented in the data analyzed. A complete listing of the individual tests applied to each data set can be found in Appendix A.
A set of numbers is said to be drawn *with replacement* if a number can be selected multiple times within the same draw. A set of numbers is said to be drawn *without replacement* if a number can only be selected once within the same draw.

Data Set	Range	Positions	Replacement	Draws
Single5	0-4	1	N/A	5,000,000
Single10	0-9	1	N/A	10,000,000
Single63	0-62	1	N/A	50,000,000
Single100	0-99	1	N/A	100,000,000
Reel20	0-19	5	N/A	20,000,000
Reel40	0-39	5	N/A	50,000,000
Reel64	0-63	5	N/A	50,000,000
Reel79	0-78	5	Yes	100,000,000
Reel114	0-113	5	Yes	100,000,000
Reel174	0-173	5	Yes	200,000,000
RespinReel1	0-9	7	(1)	10,000,000
RespinReel2	0-9	7	(1)	10,000,000
RespinReel3	0-9	7	(1)	10,000,000
RespinReel5	0-9	7	(1)	10,000,000
PartySymbol	0-5	1	(2)	5,000,000
Binary Data	0-255	1	N/A	3*12,000,000

Table 2. Game Parameters.

1. The “RespinReel” sets are based on different weights and are therefore return 7 symbols according to the game rules.
2. The “PartySymbol” set returns one symbol based on a weighted distribution.

For a summary of the statistical tests applied to each data set, see *Appendix A*. For a description of the overall test methodology and a description of each test used, see *Appendix B*.

Overall, the RNG passed the battery of tests for each configuration at the 95%, 98% and 99% confidence levels.

SECTION V — SUMMARY

Overall Evaluation of the Random Number Generator

GLI’s conclusion based upon the tests applied to the Fortuna RNG data is that this random number generator has exhibited random behavior and is suitable for the applications as described herein. If a game utilizes a different range or a different number of selections from the included ranges, the RNG should be resubmitted to test that set of parameters.

RNG Evaluation

APPENDIX A: Statistical Test Summary

Data Set	Range	Positions	Replacement	Draws	Test Names										
					Runs	Serial Corr.	Interplay Correlation	Adj. Max-Min	Adj. High-Low	Vertical Coupon	Duplicates	Overlaps	Tot. Dist.	Tot. Dist. by Pos.	DieHard.
Single5	0-4	1	N/A	5,000,000	X	X				X	X	X	X		
Single10	0-9	1	N/A	10,000,000	X	X				X	X	X	X		
Single63	0-62	1	N/A	50,000,000	X	X				X	X	X	X		
Single100	0-99	1	N/A	100,000,000	X	X				X	X	X	X		
Reel20	0-19	5	N/A	20,000,000	X	X	X	X	X	X	X	X	X	X	
Reel40	0-39	5	N/A	50,000,000	X	X	X	X	X	X	X	X	X	X	
Reel64	0-63	5	N/A	50,000,000	X	X	X	X	X	X	X	X	X	X	
Reel79	0-78	5	Yes	100,000,000	X	X	X	X	X	X	X	X	X	X	
Reel114	0-113	5	Yes	100,000,000	X	X	X	X	X	X	X	X	X	X	
Reel174	0-173	5	Yes	200,000,000	X	X	X	X	X	X	X	X	X	X	
RespinReel1	0-9	7	(1)	10,000,000	X	X							X	X	
RespinReel2	0-9	7	(1)	10,000,000	X	X							X	X	
RespinReel3	0-9	7	(1)	10,000,000	X	X							X	X	
RespinReel5	0-9	7	(1)	10,000,000	X	X							X	X	
PartySymbol	0-5	1	(2)	5,000,000		X							X		
Binary Data	0-255	1	N/A	3*12,000,000											X

Table A.1. Tests Applied

1. The “RespinReel” sets are based on different weights and therefore return 7 symbols according to the game rules.
2. The “PartySymbol” set returns one symbol based on a weighted distribution.

RNG Evaluation

APPENDIX B: Test Descriptions

Definitions.
The following terms apply to the below test descriptions. Randomness Device or Random Number Generator (RNG) output may be collected multiple numbers at a time. Each set of numbers is called a draw. Each individual number has a particular order within the *draw*. This is referred to as the number *position*.

Distribution Comparisons.
Many of the tests compare an observed numerical distribution with an expected distribution. Unless otherwise specified, this is done by means of a statistical chi-square goodness-of-fit test. The value chi-square is computed in the standard way. If *k* is a possible value, o_k is the observed count of that value, and e_k is the expected count:

$$\chi^2 = \sum_k \frac{(o_k - e_k)^2}{e_k}$$

In the case where expected counts are too small for accurate use of the above formula, values are 'binned' together to ensure an appropriate minimum expected count. The resultant value for chi-square is compared against the distribution for the appropriate number of degrees of freedom. Unusually high (distribution mismatch) or unusually low (insufficient randomness) chi-square values can be causes for data failure.

Meta-testing.
Evaluation of groups of *p*-values may include a meta-test for extremity of high or low *p*-values, a meta-test for frequency of high or low *p*-values, and a meta-test for uniformity of *p*-values, as appropriate.

Confidence Level.
The statistical tests conducted by GLI are done at a particular *confidence level*. Common confidence levels used include 95%, 98% and 99%, depending on jurisdictional requirements, and intended use of the RNG. High confidence level testing has low risk of mistakenly failing a good RNG, but higher risk of passing a bad RNG. Lower confidence level testing has increased power of detecting bad RNGs, while also increasing the risk of false failures of good RNGs. Specifically, the confidence level represents the probability that an ideal source of randomness would pass the testing. If an RNG passes statistical tests at a given confidence level, passage at all *higher* confidence levels is implied.

Tests. Some tests are only applicable to certain types of data. Some tests may be applied only to a portion of the data. Some tests may require that the data be parsed, binned, or otherwise transformed, as necessitated by data format.

RNG Evaluation

Adjacency High-Low:
For each draw, the number of local extrema ('highs' and 'lows') in the data is recorded and compared with the expected distribution. These are also referred to as 'turning points'. For example, if a draw consists of the numbers:

$$1, 3, 5, 7, 2, 9$$

there would be one local maximum (7) and one local minimum (2). The resulting statistic would be 2.

Adjacency Max-Min:
For each draw, the difference between the maximum and minimum values is calculated and recorded. This is compared with the expected theoretical distribution. For example, if a draw consists of the numbers:

$$2, 3, 6, 7, 4$$

the resulting statistic would be 5, the difference between the maximum value (7) and the minimum value (2).

Coupon Collector's:
The Coupon Collector's Test is applied positionally. The data is parsed until all possible values have been observed, then the number of values checked is recorded and the count is restarted. This is compared with the expected distribution. For example, if the set of all possible values is {0, 1, 2} and the first position of each draw is:

$$1, 0, 1, 0, 2, 0, 1, 2, \ldots$$

then all values are observed in the first position by the fifth draw. All values are then observed within the next 3 draws, so the first two statistics for the first position would be 5 and 3.

DieHard:
The DieHard Battery of Tests is a standard assessment of the randomness in raw outcomes generated from an RNG. The collection, designed by George Marsaglia, tests for a variety of patterns in the individual binary bits of RNG output. GLI uses a custom implementation to conduct DieHard testing.

Duplicates:
The Duplicates Test counts the number of times a draw is exactly duplicated in the data. In the case that a particular draw is repeated more than twice, every possible way to generate a duplicate is counted. This is compared against the theoretical distribution to verify that the number of duplicate draws falls within expected bounds. For example, consider the dataset consisting of the following draws of two numbers each.

$$a)\ 1, 3$$
$$b)\ 4, 1$$
$$c)\ 1, 3$$
$$d)\ 1, 3$$
$$e)\ 4, 1$$
$$f)\ 3, 1$$

The duplicate pairs are (*a,c*), (*a, d*), (*c, d*), and (*b, e*), for a total of 4 duplicates. *(f)* is not counted as a duplicate since the draw must match in order as well as values.

Interplay Correlation:
The Interplay Correlation Test measures statistical correlation between different positions of the same draw. For each pair of positions, statistical correlation is calculated as in the Serial Correlation Test. In the case of without replacement data, an adjustment is made to account for the expected resulting negative correlation.

RNG Evaluation

Overlaps:
The Overlaps Test compares consecutive draws for overlapping values. The number of overlapping values is recorded for each pair of draws. This observed distribution of overlaps is then compared against the expected distribution. For example, if the following draws are observed consecutively,

$$a)\ 1, 4, 5, 6$$
$$b)\ 4, 1, 7, 6$$

the number of overlaps would be 3, representing the values 1, 4 and 6.

Runs:
The Wald-Wolfowitz Runs Test is applied to each position within the draw. A center is established, typically the data median, and the number of 'runs' above and below the center are tallied. Values exactly equal to the center are discarded. This is compared to the expected distribution, which depends on the number of values above and below the center. For example, if the numbers drawn at a particular position were:

$$2, 3, 1, 5, 4, 7, 3, 2, 3, 2, 3, 2, 6, 7, 3, 5$$

and the established center were the data median of 3, the data would be parsed for runs above 3 and runs below 3.

$$\underbrace{2, 3, 1}, \overbrace{5, 4, 7, 3}, \underbrace{2, 3, 2, 3, 2}, \overbrace{6, 7, 3, 5}$$

This would be counted as 4 runs.

Serial Correlation:
The Serial Correlation Test measures statistical correlation between consecutive draws of the same position. For each position, the sample Pearson correlation coefficient is calculated. If *X* represents the first number, and *Y* the number that follows, then the coefficient is

$$r = \frac{cov(X, Y)}{s_X s_Y}$$

where *s* denotes the sample standard deviation. The coefficients are used to generate a *p*-value for each position.

Total Distribution:
The Total Distribution Test is a simple tally of all observed values throughout the data. This is compared with the expected distribution. Typically the expected distribution is a uniform distribution. In the case of unequal weighting of values, an appropriate discrete distribution is used.

Total Distribution by Position:
The Total Distribution by Position Test tallies the observed distribution of values for each position within the draw. Each of these distributions is then compared with the expected.

Conditions of Evaluation

GLI's compliance evaluation of Nolimit City Limited's "Fortuna Random Number Generator (RNG)" is subject to the following conditions:

- This Report is only intended for recipients authorized by GLI. By accepting this Report the recipient acknowledges and agrees to all of the "Terms and Conditions" set forth below. If the recipient does not agree to all of such terms and conditions, GLI withdraws the certification or analysis established by this Report and the recipient must immediately return to GLI all copies of this Report and make no reference to this Report for any purpose at any time.

- GLI's compliance evaluation of Nolimit City Limited's "Fortuna Random Number Generator (RNG)" was related only to the technical scope of work elements discussed herein. This specifically excludes any other features or functions provided by the submission not related to these elements.

- GLI's findings concerning any statistical analysis of the "Fortuna Random Number Generator (RNG)" are within 95.0%, 98.0% and 99.0% confidence intervals (varies depending on specific test).

- The tested RNG may only be used in connection to games which call the RNG with numbers within the ranges as specified in this Report.

- GLI's evaluation to the Technical Standards was limited only to the requirements applicable to the "Fortuna Random Number Generator (RNG)". In addition, the following sections of the applicable Technical Standards were excluded from the scope of work for this evaluation:

Technical Standard Section(s)	Reason for Exclusion
All sections except section 3.3.	These sections are not applicable to RNG's

- All testing results are based on information and materials submitted by Nolimit City Limited to GLI throughout the duration of the project. There are inherent limitations to performing compliance testing within a laboratory environment, and within a finite time period. As a result of these limitations, anticipating all possible configurations, scenarios and events which could potentially occur in the live environment was not feasible.

- GLI generated the checksums of the software and source code files using the methods stated below:

GLI Verify® and Verify+ by Kobetron™ - Verification Procedure for Files or Directories:

1. Open Verify+ by Kobetron™ or GLI Verify®.
2. Select the "File" or "Directory" radio button option.
3. Select the "Browse" button and then choose the file or the top directory for which a signature is being requested.
4. Click the "Verify" button.
5. The current File/Directory being checked will be displayed in the window.
6. The program will generate a CDCK, SHA-1 and MD5 signature and display the results in the centre window.

Conclusion

Subject to the **Conditions of Evaluation**, GLI has determined that product “Fortuna Random Number Generator (RNG)” submitted by Nolimit City Limited complies with the requirements of the applicable Technical Standards in the jurisdiction of Curacao Online as regulated by the Curacao Gaming Control Board.

If you should have any questions regarding this information, please feel free to contact our office.

Sincerely,

John van Schaijk
Technical Director

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