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October 17, 2017

Mr. Stephen Barnes
Arrontech Software Ltd.
14th Floor of China Hong Kong Tower
Room 1401, 8 Hennessy Road
Wan Chai, Hong Kong

RE: Random Number Generator Report

Dear Mr. Barnes:

Enclosed, please find a detailed explanation of the Random Number Generator (RNG) testing results of the Realtime Gaming (RTG) RNG version 1.0.0.2, submitted by Arrontech Software Ltd. on behalf of Realtime, for use with standard card games for GLI-19 - Interactive Gaming Systems v2.0.

Please visit Gaminglabs.com to view the applicable Terms and Conditions.

If you should have any questions regarding this Random Number Generator Report, please feel free to contact our office.

Sincerely,

GAMING LABORATORIES INTERNATIONAL, LLC

Christine M. Gallo

Vice President of Technical Compliance and Quality Assurance

ENCLOSURES

RN-120-ARN-17-01

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RANDOMNESS REPORT FOR THE REALTIME GAMING RNG VERSION 1.0.0.2

The intent of this report is to indicate that **Gaming Laboratories International, LLC (GLI)** has completed its evaluation of the Realtime Gaming (RTG) random number generator (RNG), version 1.0.0.2, provided by Arrontech Software Ltd.

SECTION I – SCOPE OF TESTING

On behalf of Realtime Gaming, Arrontech Software Ltd. submitted the required materials, to GLI in order to conduct a random number generator analysis on the Realtime Gaming RNG version 1.0.0.2. The scope of this analysis was limited to software verification and source code review. The data analysis results from previous testing have been leveraged for this evaluation and the results are detailed herein. The RNG was tested for its ability to randomly produce outcomes for use with standard card games.

SECTION II – SOFTWARE VERIFICATION

During the analysis there were digital signatures taken of the compiled key RNG files provided. The GLI Verify® (Version 6.0) signatures are as follows:

File	Version	Type	Signature
		CDCK	ED39
RNG.dll	1.0.0.2	SHA-1	F184C6F1D9EA36491ADDA383FA8166FF44061653
		SHA-256	739FC8ED30D147BBF30EA8036E30F7BB97F2216982757047F889CE2D59261DA6
		MD5	FEA6223F2002D8C3DA6E27A54ADF1A60

Table 1. Digital Signatures

SECTION III – SOURCE CODE REVIEW

On behalf of Realtime Gaming, Arrontech Software Ltd. 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.

Please note that the R250 algorithm implemented is not cryptographically strong on its own, however when used in conjunction with the seeding, background cycling, scaling, and other random burning of numbers by the system this results in a strong enough implementation for generation of random values for the data parameters detailed within the scope of this project.

SECTION IV – DATA ANALYSIS

The game configuration and parameters for the data previously obtained and tested are listed in Table 2 and have been carried over from previous testing. A complete listing of the individual tests applied to each data set can be found in Appendix A.

Data Set	Range
Standard Card Games	0-51
Binary Data	0-1

Table 2. Game Parameters

Three Binary Data sets were collected and analyzed for application of the DieHard Suite of Tests.

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*. The statistical testing was applied at the 95%, 98%, and 99% confidence levels.

Overall, the RNG passed the battery of tests for each configuration at the confidence levels applied.

SECTION V - SUMMARY

Overall Evaluation of the Random Number Generator

GLI's conclusion based upon the tests applied to the Realtime Gaming RNG version 1.0.0.2 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.

APPENDIX A: Statistical Test Summary

Data Set	Range	Tests Names			
		Successive Pairs	Coupon	Tot. Dist.	DieHard
Standard Card Games	0-51	X	X	X	
Binary Data	0-1				X

Table A-1. Tests Applied

APPENDIX B: Test Descriptions

B.1 Definitions. The following terms apply to the below test descriptions. RNG output is often 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*.

B.2 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.

B.3 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.

B.4 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.

B.5 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.

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, . . . ,

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.

Successive Pairs:

The Successive Pairs Test tallies the observed occurrences of each of the possible successive pairs values and compares them against the expected distribution.

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.