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April 9, 2018

Mr. Daniel Huang, Chief Executive Officer
KA System Global Ltd.
3F-1, No. 501, Section 2, Tiding Blvd.
Taipei, Taiwan

RE: Random Number Generator Report (**Gaming Laboratories International, LLC** Proposal # VN-KA System-01-02-180115 dated January 15, 2018)

Dear Mr. Huang:

Enclosed, please find a detailed explanation of the Random Number Generator (RNG) testing results of the KA System Global Ltd. RNG, for use with Bakery Sweetness, Ares God of War, Flaming 7, Super Video Poker and Super Keno games, evaluated against the RNG-specific requirements listed herein.

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-127-KAS-18-01

cc

RANDOMNESS REPORT FOR THE KA SYSTEM GLOBAL LTD. RNG

The intent of this report is to indicate that **Gaming Laboratories International, LLC (GLI)** has completed its evaluation of the KA System Global Ltd. random number generator (RNG), provided by KA System Global Ltd.

SECTION I – SCOPE OF TESTING

KA System Global Ltd. submitted the required materials to GLI in order to conduct a random number generator analysis on the KA System Global Ltd. 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 Bakery Sweetness, Ares God of War, Flaming 7, Super Video Poker and Super Keno games.

The KA System Global Ltd. RNG was evaluated against the RNG-specific requirements of the following technical standards:

- The Gambling Supervision Commission's Statutory Document Number 731/07 Online Gambling (Systems Verification) (No.2) Regulations 2007, laid before Tynwald 16th October 2007, coming into operation 31st August 2007.

SECTION II – SOFTWARE VERIFICATION

Verify+ by Kobetron™ signatures for the KA System Global Ltd. RNG are as follows:

File	Type	Signature
KARNG.jar	Kobe4	8CF5
	MD5	FB50C923A63F34950C1422C80E90B596
	SHA-1	B8D8313C9C178FFE5A41DB3E78C08463316ADD77

Table 1. Digital Signatures

Data Set	Game ID	Range	Positions	Replacement	Draws
Ares God of War – 11	Ares	0-3,200	1	N/A	2,000,000,000
Ares God of War – 12	Ares	0-3,400	1	N/A	1,000,000,000
Ares God of War – 13	Ares	0-4,300	1	N/A	1,000,000,000
Ares God of War – 14	Ares	0-4,400	1	N/A	1,000,000,000
Ares God of War – 15	Ares	0-4,500	1	N/A	1,000,000,000
Ares God of War – 16	Ares	0-5,900	1	N/A	2,000,000,000
Ares God of War – 17	Ares	0-6,300	1	N/A	2,000,000,000
Ares God of War – 18	Ares	0-6,400	1	N/A	2,000,000,000
Ares God of War – 19	Ares	0-14	15	No	20,000,000
Ares God of War – 20	Ares	0-50	5	Yes	10,000,000
Ares God of War – 21	Ares	0-54	5	Yes	10,000,000
Ares God of War – 22	Ares	0-60	5	Yes	50,000,000
Ares God of War – 23	Ares	0-63	5	Yes	20,000,000
Bakery Sweetness – 1	Bakery	0-45	20	Yes	50,000,000
Bakery Sweetness – 2	Bakery	0-47	20	Yes	10,000,000
Bakery Sweetness – 3	Bakery	0-65	20	Yes	20,000,000
Bakery Sweetness – 4	Bakery	0-66	20	Yes	20,000,000
Bakery Sweetness – 5	Bakery	0-71	20	Yes	20,000,000
Bakery Sweetness – 6	Bakery	0-73	20	Yes	20,000,000
Bakery Sweetness – 7	Bakery	0-88	20	Yes	20,000,000
Bakery Sweetness – 8	Bakery	0-103	20	Yes	20,000,000
Bakery Sweetness – 9	Bakery	0-186	20	Yes	100,000,000

Data Set	Game ID	Range	Positions	Replacement	Draws
Flaming 7 – 1	Flaming7	0-239	3	Yes	50,000,000
Flaming 7 – 2	Flaming7	0-259	3	Yes	200,000,000
Flaming 7 – 3	Flaming7	0-269	3	Yes	100,000,000
Flaming 7 – 4	Flaming7	0-279	3	Yes	100,000,000
Flaming 7 – 5	Flaming7	0-289	3	Yes	100,000,000
Flaming 7 – 6	Flaming7	0-299	3	Yes	100,000,000
Flaming 7 – 7	Flaming7	0-309	3	Yes	100,000,000
Flaming 7 – 8	Flaming7	0-609	3	Yes	500,000,000
Super Keno – 1	SuperKeno	1-80	20	No	100,000,000
Super Keno – 2	SuperKeno	0-79	1	N/A	100,000,000
Super Video Poker	SuperVideoPoker	0-51	52	No	50,000,000
Binary	N/A	0-65,535	1	N/A	6,000,000

Table 2. Game Parameters

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 KA System Global Ltd. 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.

The software being certified herein is a cryptographically strong RNG (CSRNG) without background cycling. CSRNGs do not need to implement background cycling to improve their unpredictability and resistance to attack. They meet and exceed the intent of traditional background cycling requirements, but through mechanisms other than background cycling itself.

APPENDIX A: Statistical Test Summary

					Test Names												
					Runs	Serial Corr.	Interplay Corr.	Adj. Max-Min	Adj. High-Low	Adj. Blocks	Coupon	Duplicates	Overlaps	Tot. Dist.	Tot. Dist. by Pos.	Count of Counts	DieHard
Data Set	Range	Positions	Replacement	Draws													
Ares God of War – 1	0-99	1	N/A	20,000,000	X	X						X	X	X	X		
Ares God of War – 2	0-49	1	N/A	10,000,000	X	X						X	X	X	X		
Ares God of War – 3	0-32	1	N/A	10,000,000	X	X						X	X	X	X		
Ares God of War – 4	0-34	1	N/A	10,000,000	X	X						X	X	X	X		
Ares God of War – 5	0-43	1	N/A	10,000,000	X	X						X	X	X	X		
Ares God of War – 6	0-44	1	N/A	10,000,000	X	X						X	X	X	X		
Ares God of War – 7	0-45	1	N/A	10,000,000	X	X						X	X	X	X		
Ares God of War – 8	0-59	1	N/A	20,000,000	X	X						X	X	X	X		
Ares God of War – 9	0-63	1	N/A	20,000,000	X	X						X	X	X	X		
Ares God of War – 10	0-64	1	N/A	20,000,000	X	X						X	X	X	X		
Ares God of War – 11	0-3,200	1	N/A	2,000,000,000	X	X							X		X		

					Test Names												
					Runs	Serial Corr.	Interplay Corr.	Adj. Max-Min	Adj. High-Low	Adj. Blocks	Coupon	Duplicates	Overlaps	Tot. Dist.	Tot. Dist. by Pos.	Count of Counts	DieHard
Data Set	Range	Positions	Replacement	Draws													
Ares God of War – 12	0-3,400	1	N/A	1,000,000,000	X	X						X	X	X	X		X
Ares God of War – 13	0-4,300	1	N/A	1,000,000,000	X	X						X	X	X	X		X
Ares God of War – 14	0-4,400	1	N/A	1,000,000,000	X	X						X	X	X	X		X
Ares God of War – 15	0-4,500	1	N/A	1,000,000,000	X	X						X	X	X	X		X
Ares God of War – 16	0-5,900	1	N/A	2,000,000,000	X	X						X	X	X	X		X
Ares God of War – 17	0-6,300	1	N/A	2,000,000,000	X	X						X	X	X	X		X
Ares God of War – 18	0-6,400	1	N/A	2,000,000,000	X	X						X	X	X	X		X
Ares God of War – 19	0-14	15	No	20,000,000	X	X	X						X		X	X	
Ares God of War – 20	0-50	5	Yes	10,000,000	X	X	X	X	X			X	X	X	X	X	
Ares God of War – 21	0-54	5	Yes	10,000,000	X	X	X	X	X			X	X	X	X	X	
Ares God of War – 22	0-60	5	Yes	50,000,000	X	X	X						X		X	X	

					Test Names											
					Runs	Serial Corr.	Interplay Corr.	Adj. Max-Min	Adj. High-Low	Adj. Blocks	Coupon	Duplicates	Overlaps	Tot. Dist.	Tot. Dist. by Pos.	Count of Counts
Data Set	Range	Positions	Replacement	Draws												
Ares God of War – 23	0-63	5	Yes	20,000,000	X	X	X	X	X		X	X	X	X	X	
Bakery Sweetness – 1	0-45	20	Yes	50,000,000	X	X	X					X		X	X	
Bakery Sweetness – 2	0-47	20	Yes	10,000,000	X	X	X	X	X		X	X	X	X	X	
Bakery Sweetness – 3	0-65	20	Yes	20,000,000	X	X	X	X	X		X	X	X	X	X	
Bakery Sweetness – 4	0-66	20	Yes	20,000,000	X	X	X	X	X		X	X	X	X	X	
Bakery Sweetness – 5	0-71	20	Yes	20,000,000	X	X	X	X	X		X	X	X	X	X	
Bakery Sweetness – 6	0-73	20	Yes	20,000,000	X	X	X	X	X		X	X	X	X	X	
Bakery Sweetness – 7	0-88	20	Yes	20,000,000	X	X	X	X	X		X	X	X	X	X	
Bakery Sweetness – 8	0-103	20	Yes	20,000,000	X	X	X	X	X		X	X	X	X	X	
Bakery Sweetness – 9	0-186	20	Yes	100,000,000	X	X	X					X		X	X	
Flaming 7 – 1	0-239	3	Yes	50,000,000	X	X	X	X	X		X	X	X	X	X	

					Test Names												
					Runs	Serial Corr.	Interplay Corr.	Adj. Max-Min	Adj. High-Low	Adj. Blocks	Coupon	Duplicates	Overlaps	Tot. Dist.	Tot. Dist. by Pos.	Count of Counts	DieHard
Data Set	Range	Positions	Replacement	Draws													
Flaming 7 – 2	0-259	3	Yes	200,000,000	X	X	X					X		X	X		
Flaming 7 – 3	0-269	3	Yes	100,000,000	X	X	X	X	X		X	X	X	X	X		
Flaming 7 – 4	0-279	3	Yes	100,000,000	X	X	X	X	X		X	X	X	X	X		
Flaming 7 – 5	0-289	3	Yes	100,000,000	X	X	X	X	X		X	X	X	X	X		
Flaming 7 – 6	0-299	3	Yes	100,000,000	X	X	X	X	X		X	X	X	X	X		
Flaming 7 – 7	0-309	3	Yes	100,000,000	X	X	X	X	X		X	X	X	X	X		
Flaming 7 – 8	0-609	3	Yes	500,000,000	X	X	X					X		X	X		
Super Keno – 1	1-80	20	No	100,000,000	X	X	X					X		X	X		
Super Keno – 2	0-79	1	N/A	100,000,000	X	X						X			X		
Super Video Poker	0-51	52	No	50,000,000	X	X	X					X		X	X		
Binary	0-65,535	1	N/A	6,000,000													X

Table A 1. Tests Applied

APPENDIX B: Test Descriptions

B.1 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*.

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.

Adjacency Blocks:

For each draw, the data is first sorted. Then the amount of contiguous blocks of numbers is counted. These statistics are then compared against the expected. For example, if a draw consists of the numbers

1, 5, 4, 2, 6, 9

the data would be sorted and separated into blocks. The resulting statistic would be 3.

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).

Count of Counts:

The Count of Counts test first counts the occurrences of each value in each position of the data. These counts are then tallied and compared with the expected distribution of counts for the draw size and range of values.

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.

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.

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.

2, 3, 1, 5, 4, 7, 3, 2, 3, 2, 3, 2, 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.