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Issuing Laboratory GLI Europe B.V.

Evaluating Laboratory GLI Europe B.V.

Recipient Playtech Software Limited
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Alderney:

- Alderney - Technical Standards and Guidelines for Internal Control Systems and Internet Gambling Systems Version 4.2.

Gibraltar:

- Remote Technical and Operating Standards for the Gibraltar Gambling Industry - v1.1.0.
- Gambling Commissioner's Guidelines - v.1.0.2012.
- Gambling Act 2005 - Act. No. 2005-72 Commencement (LN. 2006/114) except for s. 55(b) 26.10.2006 Assent 22.12.2005.

Isle of Man:

Tested against Requirements

- 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.

Malta Online:

- L.N. 243 of 2018 - GAMING ACT (CAP. 583) Gaming Authorisations Regulations, 2018.
- Directive 2 of 2018 - Player Protection Directive.

UK Remote:

- Remote Gambling and Software Technical Standards (June 2017).
- Testing Strategy for Compliance with Remote Gambling and Software Technical Standards November 2018.

Jurisdiction Alderney
Isle of Man
Gibraltar
Malta Online
UK Remote

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Product Name Playtech Software RNG, version 20.1.1.6

FM-QA-077

Template Revision Date: 1 November 2019





Description of the Product Tested SecureRandomX.class
RandomX.class
As requested per submitter's letter received 9 January 2020

Evaluation Period 13 January 2020 / 6 March 2020

Internal Reference RN-556-PVI-20-01-246

Result Pass (See Comments and Conditions on the following pages)

Internal methods used reference Random Number Generator (RNG) Analysis
WI-MA-006, PC-TC-001

Technical Evaluation authorized by:

Martin Britton
Managing Director





RANDOMNESS REPORT FOR THE PLAYTECH SOFTWARE RNG

The intent of this report is to indicate that **Gaming Laboratories International, LLC (GLI)** has completed its evaluation of the Playtech Software random number generator (RNG), 20.1.1.6, provided by Playtech Software Limited (Isle of Man).

SECTION I — SCOPE OF TESTING

Playtech Software Limited (Isle of Man) submitted the required materials to GLI in order to conduct a random number generator analysis on the Playtech Software 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 ranges up to and including 2,147,483,647.

The Playtech Software RNG was evaluated against the RNG-specific requirements of the following technical standards:

- Alderney:
 - Alderney - Technical Standards and Guidelines for Internal Control Systems and Internet Gambling Systems Version 4.2.
- Gibraltar:
 - Remote Technical and Operating Standards for the Gibraltar Gambling Industry - v1.1.0
 - Gambling Commissioner's Guidelines - v.1.0.2012
 - Gambling Act 2005 - Act. No. 2005-72 Commencement (LN. 2006/114) except for s. 55(b) 26.10.2006 Assent 22.12.2005.
- Isle of Man:
 - 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.
- Malta Online:
 - L.N. 243 of 2018 - GAMING ACT (CAP. 583) Gaming Authorisations Regulations, 2018.
 - Directive 2 of 2018 - Player Protection Directive.
- UK Remote:
 - Remote Gambling and Software Technical Standards (June 2017).
 - Testing Strategy for Compliance with Remote Gambling and Software Technical Standards November 2018.

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. As a consequence, they meet and exceed the intent of traditional background cycling requirements, but through mechanisms other than background cycling.



SECTION II — SOFTWARE VERIFICATION

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

File	Version	Type	Signature
SecureRandomX.class	20.1.1.6	Kobe4	F8CU
		MD5	6F09D19ED0C4B5E283E2D1B3B29A21D7
		SHA-1	35D129020D9804981DF894668D9DAD6B3AC07053
		Kobe40	2236176F16A824A227C953123C7F43HC28P556P5
		CDCK	68FC
RandomX.class	20.1.1.6	Kobe4	P28U
		MD5	81A9AC042D810424ADD529FBA563C243
		SHA-1	45C872A864050C28F55C3BF16641D6696FECC89C
		Kobe40	260018C47C5UHP64FF2F2HAHC331CFAH31UCA38H
		CDCK	8C48

Table 1. Digital Signatures

SECTION III — SOURCE CODE REVIEW

Playtech Software Limited (Isle of Man) 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.

GLI conducted a statistical analysis of sufficient scope to test the RNG for general with- and without- replacement use, for all possible game ranges up to and including 2,147,483,647 as described in Table 2. The selection of test cases took into account broad coverage of range sizes and selections.

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
General Certification	Up to and including 2,147,483,647	Any	Yes and No	①
Binary for Diehard	0-2,147,483,646	1	N/A	3,096,775

Table 2. Game Parameters

① Data sets of different ranges and draw sizes were collected and analyzed to cover the scope of this general certification.

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 Playtech Software 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.



APPENDIX A: Statistical Test Summary

Data Set	Range	Positions	Replacement	Draws	Test Names														
					Runs	Serial Corr.	Interplay Corr.	Adj. Max-Min	Adj. High-Low	Adj. Blocks	Coupon	Duplicates	Overlaps	Permutation	Tot. Dist.	Tot. Dist. by Pos.	Count of Counts	Diehard	
General Certification	Up to and including 2,147,483,647	Any	Yes and No	①	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Binary for Diehard	0-2,147,483,646	1	N/A	3,096,775															X

Table A 1. Tests Applied

① Data sets of different ranges and draw sizes were collected and analyzed to cover the scope of this general certification.



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.



APPENDIX B: Test Descriptions

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.



APPENDIX B: Test Descriptions

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.

Permutation:

The Permutation Test is a test applicable to data that represents a reordering of numbers. Each draw can be considered as a permutation of the original ordering. Every permutation can be decomposed into disjoint cycles, which represent the possible positions a number would occupy if the same permutation is applied repeatedly. For each draw, three statistics are collected based on the cycle decomposition:

- The number of cycles.
- The size of the smallest cycle.
- The size of the largest cycle.

Each of these statistics generates a distribution of observations which are compared with their respective expected distributions. For example, if the following draw were observed as a reordering of the numbers from 1 to 6,

1, 3, 5, 4, 2, 6

the cyclic decomposition would be $(1)(2\ 3\ 5)(4)(6)$. 1, 4, and 6 remain in their original positions, so they form their own cycles. The values 2, 3, and 5 are shuffled, so they form a single cycle together. The total number of cycles is 4, the smallest cycle has size 1, and the largest cycle has size 3.



APPENDIX B: Test Descriptions

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.



Jurisdictional Requirements

GLI’s evaluation to the Technical Standard was limited only to the requirements applicable to the Playtech Software RNG, version 20.1.1.6. In addition, the following sections of the applicable Technical Standard were excluded from the scope of work for this evaluation:

Alderney

Technical Standard Section(s)	Reason for Exclusion
All, except requirements directly referring to Random Number Generators	RNG Evaluation only
4.3.5.iv - The licensee should be able to verify that the results offered by the RNG are the same as held in the IGS after the event.	RNG Evaluation only
4.3.5.vii - As events of chance occur (e.g. due to calls to the RNG by the game), they should be immediately used as directed by the rules of the game; they are not to be discarded due to adaptive behaviour by the game.	RNG Evaluation only
4.3.5.viii - Where the rules of the game require a sequence or mapping of entities or events to be set up in advance (e.g. the position of hidden objects within a maze), the entities or events should not be re-sequenced or remapped except as provided for in the rules of the game.	RNG Evaluation only
4.3.5.x - Determination of events of chance should not be influenced, affected or controlled by anything other than numerical values derived in an approved manner from the verified RNG in conjunction with the rules of the game. This does not prohibit metamorphic games or jackpots determined by means other than individual game outcome from being considered on a case-by-case basis.	RNG Evaluation only

Isle of Man

Technical Standard Section(s)	Reason for Exclusion
All, except requirements directly referring to Random Numbers Generators.	RNG Evaluation only

Gibraltar

Technical Standard Section(s)	Reason for Exclusion
11.2 – Mechanical RNGs	Not a Mechanical RNG



Jurisdictional Requirements

GLI's evaluation to the Technical Standard was limited only to the requirements applicable to the Playtech Software RNG, version 20.1.1.6. In addition, the following sections of the applicable Technical Standard were excluded from the scope of work for this evaluation (continued):

Malta Online

Technical Standard Section(s)	Reason for Exclusion
All, except requirements directly referring to Random Numbers Generators.	RNG Evaluation only

UK Remote

Technical Standard Section(s)	Reason for Exclusion
7A - Where lotteries use the outcome of other events external to the lottery, to determine the result of the lottery the outcome must be unpredictable and externally verifiable.	Not a lottery
7A.b - For lotteries using external events - where it is not practical to demonstrate 7a.	Not a lottery
7A.c - For games or virtual events that use the laws of physics to generate the outcome of the game (mechanical RNGs), the mechanical RNG used should be capable of meeting the requirements in a. where applicable and in addition:	Not a mechanical RNG
7A.d - Restricting adaptive behaviour prohibits automatic or manual interventions that change the probabilities of game outcomes occurring during play. Restricting adaptive behaviour is not intended to prevent games from offering bonus or special features that implement a different set of rules, if they are based on the occurrence of random events.	RNG Evaluation only

