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Random Number Generator (RNG) Certification

Product name	Random Number Generator (RNG)
Jurisdiction	United Kingdom Gambling Commission (UKGC)
Applicant	MervCF Limited
Test institute	RNG Labs International Ltd.
Type of product	Random Number Generator (RNG)

Authorised by:

John Micallef
Head of Lab
23rd December 2024

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General data

Report number	ME-UK-003-2024
Jurisdiction	UK Gambling Commission
Regulations	UKGC remote gambling and software technical standards, published February 2021, updated May 2024.
Test date	14th October 2024
Project engineer	Mr. Loc Phan Van

Applicant data

Company name	MervCF Limited
Address	Av. Pastor Diaz, Provincia de Puntarenas, Jaco, 61101, Costa Rica
Contact	Dominika Pistorova

Platform information

Supplier	Value coders
Version	1.24.12.001

1. Introduction

The intent of this report is to indicate that RNG Labs International Ltd. has completed its evaluation of the Random Number Generator (RNG), version 1.24.12.001, provided by MervCF Limited.

2. Scope of testing

MervCF Limited submitted the required materials to RNG Labs in order to conduct a random number generator analysis on the RNG. The scope of this analysis was limited to software verification, source code review, and data analysis.

The RNG was evaluated against the RNG-specific requirements of the following technical standard:

- Testing strategy for compliance with remote gambling and software technical standards, April 2022.

3. Source code review

MervCF Limited submitted appropriate documentation and FULL source code which pertains to the generation of random numbers on 14th October 2024. RNG Labs 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.

RNG Labs 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. RNG Labs assessed the ability of the RNG to produce all numbers within the desired range.

4. Test results overview

Requirements within this scope are included in this test results overview.

4.1 RNG details

RNG Description	This RNG generates secure, unpredictable random numbers within a specified range by combining cryptographically secure random bytes (crypto.randomBytes()) with a dynamically generated XOR mask for additional randomness. The numbers are scaled to the desired range using a modulo operation and written incrementally in binary format to efficiently handle large datasets. This approach ensures high-quality randomness suitable for secure applications while maintaining scalability for generating a large volume of random numbers.
RNG Version No.	1.24.12.001
Hardware/Software Base	Software

Reference	Functionality	SHA-CheckSum
new_randomWinningTicket.js	RNG	2ef14b16ced7c24bb2b279f9682b0e68f7fa6033

4.2 Scope and approach to testing and a description of all tests applied

The scope of the RNG test is narrowly focused on a rigorous evaluation of the documentation, source code, and output of the RNG specifically against RTS Implementation Guidance 7A.a, ensuring compliance with recognised international standards. This testing aims to verify that:

1. The output of the RNG is uniformly distributed across the entire output range.
2. The outcomes of games using the RNG align with expected or theoretical probabilities.

This targeted approach emphasizes security, unpredictability, and non-repeatability in number generation while ensuring the RNG meets the criteria for acceptable randomness as defined by the applicable technical standards. Here's a comprehensive detail of the scope and the approach to testing:

4.2.1 Documentation and code review

The license holder is required to submit documented references to the RNG's algorithm, which should be well-established and published in a recognised international publication. We also require access to the source code and any related recalculative procedures linked to the RNG for an in-depth review. Our approach for this part of the scope will be as follows:

- Identifying RNG Algorithm: We will thoroughly identify the RNG algorithm and research any known weaknesses associated with it to assure its integrity and security.
- Verification of RNG Internal State: The internal state of the RNG will be scrutinised to confirm its adherence to unpredictability and non-repeatability requirements.
- Verification of RNG Implementation: We will verify seeding, background cycling, minimal reseeding to ensure that the RNG implementation caters to unpredictability and non-repeatability requirements efficiently.
- Verification of RNG Output Usage: The use of the random numbers, including scaling and shuffling, will be reviewed to ensure it aligns with industry standards.
- Compilation of RNG Code: After resolving any identified issues within the code, we will compile the RNG code to ensure its operability.

4.2.2 Testing RNG output:

- Diehard Test Suite: The RNG output will undergo the stringent Diehard test suite, which applies a series of statistical tests to determine the randomness of the output. These are a battery of statistical tests for measuring the quality of a RNG's sequence of numbers and determining whether they are truly random.

- NIST Tests: The National Institute of Standards and Technology (NIST) tests will be applied to ensure the RNG output meets the national standard for randomness. These are designed to test the randomness of binary sequences produced by either hardware or software-based RNGs and consist of 15 different tests focused on various aspects of randomness.

Appendix A: Documentations & Code Review

RNG implementation

The RNG implementation uses Node.js's crypto.randomBytes() function, a cryptographically secure random number generator (CSPRNG), to produce high-quality random numbers. Each random number is generated as a 32-bit unsigned integer by reading four bytes from the secure random byte array.

To enhance unpredictability further, an XOR mask is dynamically generated for each random number using another secure random 32-bit value. This XOR operation introduces an additional layer of randomness, ensuring that even if the CSPRNG were compromised, the numbers remain highly secure and unpredictable. The resulting random number is then scaled to the desired range (min to max) using a modulo operation, preserving uniform distribution within the specified range.

Statistical analysis

In order to verify that the pseudo random numbers generated by the algorithm satisfy the 'acceptably random' requirement, the output of the RNG is subjected to a statistical analysis. This analysis consists of a series of tests that determine the chance that these numbers have not been generated by a random-like process. Each of these tests observes the behaviour of a specific aspect of the series of random numbers, and will fail if the chance that a random process has not generated these series is above a certain threshold.

These tests will verify whether the output from the RNG is uniformly distributed among the entire output range as stipulated by guidance rule 7A a. i), but is not limited to just this verification.

The software used for statistical analysis of raw output is the Dieharder RNG test suite (Brown, 2015). This is a test suite maintained by Robert G. Brown from Duke University Physics Department. It builds upon the Diehard battery of tests from George Marsaglia (Marsaglia, 1995), but also includes tests from the statistical test suite from NIST (Soto, 1999) and tests developed by Robert G. Brown himself.

The following "bitwise" tests from the NIST Test Suite were applied:

- Frequency (Monobits) Test
- Frequency Test within a Block
- Run Test
- Test for the Longest Run of Ones in a Block
- Binary Matrix Rank Test
- Discrete Fourier Transform (Spectral) Test
- Non-overlapping Template Matching Test
- Maurer's "Universal Statistical" Test
- Linear Complexity Test
- Serial Test
- Approximate Entropy Test
- Cumulative Sums (Cumsum) Test
- Random Excursions Test

- Random Excursions Variant Test

The following "bitwise" tests from the DIEHARD Battery of Tests of Randomness were applied:

- Birthday Spacing Test
- Overlapping 5-permutations Test
- Binary Rank 31×31 Test
- Binary Rank 32×32 Test
- Binary Rank 6×8 Test
- Bitstreams Test
- Overlapping Pairs Sparse Occupancy (OPSO) Test
- Overlapping Ouadruples Sparse Occupancy (OOSO) Test
- DNA Test
- Count the 1's (Specific Bytes) Test
- Count the 1's (Stream of Bytes) Test
- Parking Lot Test
- Minimum Distance Test
- 3-D Spheres Test
- Squeeze Test
- Overlapping Sums Test
- Runs Test
- Craps Test

The results of all the tests are listed in appendix B.

Source code inspection

The source code was inspected to verify that the remaining requirements 7A.a have been met. In this section for each of the requirements a brief outline is given how the source code ensures that the requirements are met.

The RNG is unpredictable

The RNG relies on Node.js's crypto.randomBytes(), which is a cryptographically secure random number generator (CSPRNG). This ensures that the random bytes used as the basis for the random numbers are derived from a high-entropy source, making them resistant to prediction or manipulation.

Each random number is further processed with a dynamically generated XOR mask, which is also derived from crypto.randomBytes(). This additional step increases the randomness and unpredictability of the output, as the XOR operation effectively combines two independent random values for each number.

The seeding is unpredictable

The operating system's entropy pool, which supplies the seed for crypto.randomBytes(), is sourced from various high-entropy, unpredictable factors such as system events, device states, and hardware randomness. These sources are designed to resist prediction, ensuring that the seed used by the CSPRNG is secure and cannot be reverse-engineered.

The RNG does not cycle or synchronise

The RNG does not exhibit cycling or synchronization, as it is built on a CSPRNG with strong entropy sources and introduces additional randomness through dynamic masking. This makes it suitable for applications requiring high-quality, independent, and non-repeating random numbers.

Shuffling

The RNG does not implement any shuffling mechanisms.

Scaling is applied properly

Scaling is implemented correctly. The random numbers are uniformly distributed across the specified range (min to max) without bias or overflow, making the RNG suitable for generating values within custom ranges.

Limitations

- Acceptable DoF:. RNG is designed to generate outputs with a high degree of freedom, suitable for cryptographic applications. It provides strong variability and uniform distribution within the specified range
- Usage: Suitable for generating independent random numbers with replacement. Not designed for shuffling or applications requiring correlated outputs.
- Security: Suitable for cryptographic secure purposes due to its reliance on crypto.randomBytes(), a CSPRNG. Ensures high unpredictability and resistance to manipulation.
- OS/System version and constraints: None

This list was identified at the best of RNG Labs knowledge by analysing the test item(s) and collecting all possible reputable information sources at the time of the testing activity.

Appendix B: Empirical Testing

Please refer to the Appendices for details of the tests applied. The test results are summarised as follows:

NIST Test suite

The NIST Tests are based on the suite of tests released by the National Institute of Standards and Technology in Special Publication 800-22, Revision 1a (revised April 2010). They test sequences of raw binary output from the RNG. There were 03 sample size data file outputs tested, comprises of: 100.000.000, 200.000.000 and 300.000.000 random numbers.

Test name	P-Value (100.000.000)	P-Value (200.000.000)	P-Value (300.000.000)	Assessment
Frequency (Monobits) Test	0.554420	0.964295	0.739918	Pass
Frequency Test within a Block	0.554420	0.153763	0.729870	Pass
Run Test	0.191687	0.657933	0.392456	Pass
Test for the Longest Run of Ones in a Block	0.897763	0.085587	0.564639	Pass
Binary Matrix Rank Test	0.595549	0.798139	0.342451	Pass
Discrete Fourier Transform (Spectral) Test	0.616305	0.419021	0.564639	Pass
Non-overlapping Template Matching Test	0.911413	0.911413	0.304126	Pass
Maurer's "Universal Statistical" Test	0.455937	0.419021	0.798139	Pass
Linear Complexity Test	0.350485	0.401199	0.455937	Pass
Serial Test	0.090936	0.401199	0.564639	Pass
Approximate Entropy Test	0.739918	0.554420	0.141256	Pass
Cumulative Sums (Cumsum) Test	0.816537	0.122325	0.816537	Pass
Random Excursions Test	0.071177	0.304126	0.088469	Pass

Random Excursions Variant Test	0.115387	0.162606	0.515932	Pass

Conclusion: The RNG is **ACCEPTED** as random at the 95% confidence interval.

DIEHARD Battery of Tests

The Diehard Tests are based on the test suite published by George Marsaglia in 1995. They test sequences of raw binary output from the RNG. There were 03 sample size data file outputs tested, comprises of: 100.000.000, 200.000.000 and 300.000.000 random numbers.

Test name	P-values (100.000.000)	P-values (200.000.000)	P-values (300.000.000)	Assessment
Birthday Spacing Test	0.29099400	0.57076806	0.07045446	Pass
Overlapping 5-permutations Test	0.18711368	0.54998849	0.27379877	Pass
Binary Rank 32x32 Test	0.71008284	0.12441873	0.30222394	Pass
Binary Rank 6×8 Test	0.95423047	0.39217665	0.62717269	Pass
Bitstreams Test	0.91846461	0.82836854	0.36842491	Pass
Overlapping Pairs Sparse Occupancy (OPSO) Test	0.43356899	0.16912664	0.38670710	Pass
Overlapping Ouadruples Sparse Occupancy (OQSO) Test	0.96101416	0.98219089	0.93829977	Pass
DNA Test	0.84699991	0.96905323	0.98087678	Pass
Count the 1's (Specific Bytes) Test	0.43565571	0.21337910	0.68099380	Pass
Count the 1's (Stream of Bytes) Test	0.58817674	0.07958346	0.92121152	Pass
Parking Lot Test	0.61642584	0.51526020	0.85083996	Pass
Minimum Distance Test	0.70951873	0.40705849	0.19877490	Pass

3-D Spheres Test	0.49378868	0.29090402	0.68787884	Pass
Squeeze Test	0.82070097	0.68021113	0.55795316	Pass
Overlapping Sums Test	0.12826625	0.08366323	0.91521945	Pass
Runs Test	0.70289509	0.31399761	0.46400304	Pass
Craps Test	0.11255398	0.71543243	0.57314016	Pass

Conclusion: The RNG is **ACCEPTED** as random at the 95% confidence interval.