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Gaming Laboratories International RNG Evaluation Report

Report N°	2015PTC435RNG00
Date	9 July 2015

Issuing Laboratory

GLI Europe B.V.

Evaluating Laboratory

GLI Europe B.V.

Recipient

Playtech Software Limited
2nd Floor, St George's Court
Upper Church Street
Douglas
Isle of Man, IM1 1EE

Tested against Requirements

- **AGCC** - Technical Standards and Guidelines for Internal Control Systems and Internet Gambling Systems, Version 3.5, 25th April 2013 and any other applicable regulation.
- **Bulgaria** - General technical and functional requirements to gaming software and communication equipment of remote gambling games. On the terms and procedure for identification and registration of the participants and information storage for the organized gambling games from distance on the territory of republic of Bulgaria and for transmitting information regarding the gambling games to a server of the national revenue agency.
- General obligatory technical requirements to the control systems of gambling games and gaming equipment.
- **France** - Arjel DET_EN_15042013 Technical Requirements File Version 1.2 of 24th September 2012, covered by article 11 of decree n°2010-509 of 18th May 2010 relative to the obligations imposed on approved online gaming or betting operators with a view to the online gaming regulatory authority controlling gaming data.
- **GLI 19** - Interactive Gaming Systems V2.0.
- **Isle of Man** - Isle of Man Online Gambling (Systems Verification Amendment) Regulations 731 – 31-08-2007.
- **Malta** - Remote Gaming Regulations, 2004 – Third Schedule Test Script.
- **UK remote** - Remote Gambling and Software Technical Standards August 2009: Updated October 2014; Testing Strategy for Compliance with Remote Gambling and Software Technical Standards – October 2014.
- **Denmark** - Testing Standards for Online Casino - SCP.01.03.EN.1.0.
- Inspection Standards for Online Casino - SCP.02.03.EN.1.0.
- **Spain Online** - Resolution of 6 October 2014 of the Gaming Regulation Board passing the provision developing the technical specifications of gaming, traceability and security which have to be fulfilled by technical gaming systems of a non-reserved nature forming the object of licences granted under the Gaming Regulation Act n° 13/2011 of 27 May.
- **Italy Online** - Decree of 10th January 2011 - Governance of games of skill and games of chance with fixed odds and non tournament card games with remote participation. Version published on 24th December 2014.

Jurisdiction

Non-Jurisdictional

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Manufacturer	Playtech Software Limited 2 nd Floor, St George's Court Upper Church Street Douglas Isle of Man, IM1 1EE
Submitter	Playtech Software Limited 2 nd Floor, St George's Court Upper Church Street Douglas Isle of Man, IM1 1EE
Product Name	Playtech Multi RNG Evaluation
Product Style	Random Number Generator Evaluation
Description of the Product Tested	Playtech TV RNG, Playtech Bingo RNG, Playtech Poker RNG, Playtech Casino RNG For further details see the Software Product Details section.
Date Received / Date Completed	25 th June 2015 / 9 th July 2015
Evaluation Period	25 th June 2015 / 25 th June 2015
Result	Pass (See Comments and Conditions on page 3)
Sections	<ul style="list-style-type: none">- Comments/Conditions- Hardware Product Details- Software Product Details- Applied Tests- Product Characteristics- RNG Analysis- Terms and Conditions



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Comments/Conditions

Comments

As from 1st July 2006, it is the manufacturer's responsibility to ensure that their product is RoHS compliant with current EU directives.

The program Verify+ by Kobetron was used to generate the SHA-1 and MD5 signatures listed in the Software Product Details section of this Report.

This non-jurisdictional Report is not intended to represent the final Report for any of the mentioned jurisdictions, it is for informational purposes only.

This Report is issued for the evaluation of the RNG only and covers the game ranges supplied in the Report.

Conditions

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.



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Hardware Product Details

There are no Hardware Product Details applicable to this Report.



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Software Product Details

Playtech TV RNG

File Name	MD5 Checksum	SHA-1 Checksum
ENG_ROULETTE.pm	34E9B3EF 7E8880D7 2B5C86B8 F296B8C7	212721F7 1E72C4CD 3E4EBA38 659BBE0E 09D48834
random.pm	63274FE1 AED17EE5 A4CCB1AA DC48C257	70C7FBB3 A9353E55 6FD2D856 58116684 B1847ABC
roulette_spots.pm	67B5AF3C C5EDBC1E B45E34C1 83BFA352	A71EC5B9 5986A27A E523B078 498F1F07 0A13DE7A

Playtech Bingo RNG

File Name	MD5 Checksum	SHA-1 Checksum
rng.properties	4FBA6E0A 683B8584 0D47B396 CA392AE1	9A2E6B48 C4E5CD6B CCDBE5CF CCD9D34A 95BDCD26
AccessCountRNGCyclingStrategy.class	8C40A603 6A3A72EB 16B72162 6284D913	B95EFC98 19232608 C216AD02 836F7A0A E92F7E7C
DefaultRNG.class	9A785B34 752455A7 AF2B89E2 789A1E9E	2C2AC97C 0D5529F4 C3158733 9590E8D2 533E1264
DefaultSecureRandom.class	2A3E69FC BD6ADFB2 FE884654 F0B16D15	2C42D303 35D61CF2 9EB22219 BA1F2E63 CA24A4C1
RandomException.class	8036871F 0CF547FB 355E74E6 91ABD848	832FEAD9 C7259793 205AED51 FB503DBC EC29F25B

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Playtech Bingo RNG (continued)

File Name	MD5 Checksum	SHA-1 Checksum
RandomNumberGenerator.class	CFF53ABA 28F502B1 08EABBB8 17C6FF1B	B68292AB 0021A39B C03B0434 E173554E DC30C83E
RandomUtils.class	E18F7B3E 5D45153A E37EE414 5080AA4C	DBAA4C48 0EAB4B6E 68D1158E 8D24255B 345072E4
RNGCyclingStrategy.class	30FE862C 5371F5F1 933F62DB CA48B6B4	BE43474B B9167780 CFE1A79E DE3A11C1 FFC17B6B
SecureRandomWrapper.class	45DCA241 D5EB7542 03A4B59F F8D6C420	2D4EAED6 642949F1 FB4D421B 60998B99 D5B22996
SpecificSecureRandom.class	6E724E42 1FA0457C 0948DEDB B165AD9B	5EC46AFD 00F221C5 5E48171D 80B8B029 DC9D2956
SunSHA1PRNGSecureRandom.class	4B95CB9A 70F199ED 5F31FCB8 A16A3C5B	53C5C7EC FEB8B8D3 69051756 84501655 CA813A10
TimedAccessRNGCyclingStrategy.class	59CEA88E F795D21D DDB70DBB 5E214F96	F7CE7A1F A8CD0C55 5CB8F3A4 F5A408B6 7E61E4D8
RNGFactoryBean.class	ED52889C 3C66695F 55196ABC 875C32B8	68DA7423 8AA08FEA CE215DDC 7ED8C79B CD762BF5

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Playtech Poker RNG

File Name	MD5 Checksum	SHA-1 Checksum
AbstractRngClientSession.class (Version 15.5.12.1)	3BD40A4A C91C5100 B358582B 83163D5E	F91DCC64 C2CD2704 EAD11FC0 E79C1887 88B6D28F
BitUtils.class (Version 15.5.12.1)	C063045B C2847578 4C6A9F13 D39859A3	2E59EC46 32085CFE 0F97F1C4 F6A56027 494D08BA
BufferLevel.class (Version 15.5.12.1)	94578A25 9A1AB58F 393B5531 081B56DA	AA311C33 5FA6A6C9 8F746BBE 26992F26 FBCB74CC
BufferLevel\$Level.class (Version 15.5.12.1)	9895A34A 28505579 43522645 C0A8A6FA	870D20DD DF42DEFF 50D8B63A 12D413C6 9F38221E
ComPortOptionHandler.class (Version 15.5.12.1)	093F2037 0314FFC3 F6225D88 635A0E20	111425E3 CFE69DD6 101226C1 425C15D6 8F5CC2C0
DriverManager.class (Version 15.5.12.1)	D0D72649 08867639 AA91EF78 EFF56CB8	DF901A7F AE9B8B58 DB549A52 DF7258B3 B35A3C3B
DriverManager\$1.class (Version 15.5.12.1)	51C9061B 59BEB948 68EBC2D2 8AD34B9A	48412290 671A101B E85E20E4 EB3064D0 0F86600E
FrequencyAnalyzer.class (Version 15.5.12.1)	4950BDC9 45773A6D 5C66B42F 2D27E297	08F8A949 A59ED95D 1693F027 87617E90 63D2CBAB
GameServerSession.class (Version 15.5.12.1)	2EE1729C 111C7450 18A14FA5 40255349	9E1E1458 D19ABE61 70B5E39A 8F9B99F9 5728FC27

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Software Product Details

Playtech Poker RNG (continued)

File Name	MD5 Checksum	SHA-1 Checksum
IRandomBuffer.class (Version 15.5.12.1)	564ED4C8 1FEA9F21 A92A4AEC C2BA3F89	740CCF39 185CCF0A 5C01EAB1 AE27963C DDAE15FF
IRandomConsumer.class (Version 15.5.12.1)	973EA1B8 CB45A64D 9E35D0BC AA5922C3	F9015CE8 7900FFA7 ED9BAFAE 70964E34 DC7FB98F
IRngDriver.class (Version 15.5.12.1)	A70294AC E827D2D8 EE69535D 8776586D	68E70ADE 00EB0B8F 84882E54 848AD0D0 A2EBB88F
NoiseBufferHelper.class (Version 15.5.12.1)	A6F897DD 5622416F 592E591F 377D791B	62B94F4C EFFBC076 6CC22B19 0E98339C 939B8DEE
PTMetrics.class (Version 15.5.12.1)	22088108 A329BAAA DAAC0804 F5DAD678	68C5339D D17B9C60 DA7AF50C BB87E643 66772ABF
PtTelnnetClient.class (Version 15.5.12.1)	094C58F4 9B3DC292 F6C49949 16CAB9DA	AFBD7147 F3CE9905 8021774C 06E4C4D2 929E3E20
RandomBatch.class (Version 15.5.12.1)	53410EC0 B6A93C31 B993EDB4 0D52336A	2DFE3BC4 DCD85488 B9071595 9129CD38 79F03A04
RandomBuffer\$1.class (Version 15.5.12.1)	DA5F7BC5 09F6D8AC C7A09054 7826239D	5EDB854D 79390C00 987426D1 FA307526 40BC84C9
RandomBuffer\$2.class (Version 15.5.12.1)	79DA7BB3 2C1949EC 65243DC7 48522298	C1A5123E D93E37DC 963CD47F ADE9C068 B937D572

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File Name	MD5 Checksum	SHA-1 Checksum
RandomBuffer.class (Version 15.5.12.1)	5EB1C30C BC12C09C 5693ECC8 B626DEE3	295D8CF5 7FFD3E1F 211D680D DC1D7E08 24D5E77B
RandomProvider.class (Version 15.5.12.1)	0B25B527 B15C56EC AD88DF9B 3DA16AFB	DA029C3C 791D7D93 2E0C8FF2 A295A725 495E02D9
RandomReader.class (Version 15.5.12.1)	F0FEC136 076646E9 B659F8A6 0394F750	8C2E5F91 38F8EE4D E42A1BE6 C8794528 242DA3DA
RandomReaderImpl.class (Version 15.5.12.1)	C2B2104F AE35A53D 7CAC38A2 184B58BD	D0BAB176 330C916F 7D8B8EF5 E65E1C09 0EAF94C5
RandomX.class (Version 15.5.12.1)	2D629A48 6B527F09 CFA79082 553BEC31	66293BA9 F6AD140C 9E71A076 D0A906DE 63BBB30A
RandomXImpl.class (Version 15.5.12.1)	318C625F 31D14F0B 952D5FF1 3195F531	EC034416 60509672 661B3C84 F354D718 F1592E8D
RandomXWrapper.class (Version 15.5.12.1)	E59C21BC 266D4AE0 CCF93912 B7B79B30	5DC10B5B 7966788D A5C24F76 94DE48B5 086E1FB7
RandomY.class (Version 15.5.12.1)	CA887074 CAC7C4C9 2D28F3D5 A0201644	46A218D1 F3719F85 5908DAFE CB6D6EBB E8B170A6
ReverseTelnetDriver.class (Version 15.5.12.1)	48DD9899 8076C94A 7AC8A2BB 2E44F3D0	D51B992F E87EB791 5AED2F01 3557B921 BB66A374

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File Name	MD5 Checksum	SHA-1 Checksum
ReverseTelnetInterface.class (Version 15.5.12.1)	10DF072A 31552DF8 051DBFB8 D1DB7E01	43C295C7 59555DD7 1155B99F 959EF009 659946F0
RngDriver.class (Version 15.5.12.1)	C673FB34 0AD0D6C4 89F05BB1 E02BCE9C	18C6B789 6790CE8D 94361363 6A1C0BA9 F515F7CC
RngDriverException.class (Version 15.5.12.1)	E49AF808 2E1C7872 2CE32918 2E3D518E	699CBB79 71BF8C16 CBCE126E 87FB5034 15CE8E7C
RngServer.class (Version 15.5.12.1)	8D9CD309 7331A376 D7A12BD0 56F3D41E	BF8C1698 05DA287B 1E8077A3 99773DFD 7DD1BE4D
SG100Driver.class (Version 15.5.12.1)	F08DF12B B42A2BAE 4949F491 D8C23F5A	6490E0C4 AFEA3A08 9240BB2D 34BA10FC E1C102D6
AbstractGameRules.class (Version 14.9.3.4)*	8F3C4CCA 06822675 F2F64B8D E7136F7F	4EB5B01E E981D6F6 3B2D97E1 B60438E8 838F4AAA
Deck.class (Version 14.9.3.4)*	0D89DA50 7A68E3AA D353B207 566ADAE6	F11820BC 825483E0 2FAA6365 B0BD5DEB 34C8E290
RealShuffler.class (Version 14.9.3.4)*	310359B3 B8567B0D 2B6510FA 1C010933	52D61E45 CF5FC979 3F1D0F31 95EA5DC0 14A28D61

* These files were taken from the Poker Game Server.



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File Name	MD5 Checksum	SHA-1 Checksum
AbstractRngClientSession.class (Version 15.5.12.1)	3BD40A4A C91C5100 B358582B 83163D5E	F91DCC64 C2CD2704 EAD11FC0 E79C1887 88B6D28F
BitUtils.class (Version 15.5.12.1)	C063045B C2847578 4C6A9F13 D39859A3	2E59EC46 32085CFE 0F97F1C4 F6A56027 494D08BA
BufferLevel.class (Version 15.5.12.1)	94578A25 9A1AB58F 393B5531 081B56DA	AA311C33 5FA6A6C9 8F746BBE 26992F26 FBCB74CC
BufferLevel\$Level.class (Version 15.5.12.1)	9895A34A 28505579 43522645 C0A8A6FA	870D20DD DF42DEFF 50D8B63A 12D413C6 9F38221E
ComPortOptionHandler.class (Version 15.5.12.1)	093F2037 0314FFC3 F6225D88 635A0E20	111425E3 CFE69DD6 101226C1 425C15D6 8F5CC2C0
DriverManager.class (Version 15.5.12.1)	D0D72649 08867639 AA91EF78 EFF56CB8	DF901A7F AE9B8B58 DB549A52 DF7258B3 B35A3C3B
DriverManager\$1.class (Version 15.5.12.1)	51C9061B 59BEB948 68EBC2D2 8AD34B9A	48412290 671A101B E85E20E4 EB3064D0 0F86600E
FrequencyAnalyzer.class (Version 15.5.12.1)	4950BDC9 45773A6D 5C66B42F 2D27E297	08F8A949 A59ED95D 1693F027 87617E90 63D2CBAB
GameServerSession.class (Version 15.5.12.1)	2EE1729C 111C7450 18A14FA5 40255349	9E1E1458 D19ABE61 70B5E39A 8F9B99F9 5728FC27

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Playtech Casino RNG (continued)

File Name	MD5 Checksum	SHA-1 Checksum
IRandomBuffer.class (Version 15.5.12.1)	564ED4C8 1FEA9F21 A92A4AEC C2BA3F89	740CCF39 185CCF0A 5C01EAB1 AE27963C DDAE15FF
IRandomConsumer.class (Version 15.5.12.1)	973EA1B8 CB45A64D 9E35D0BC AA5922C3	F9015CE8 7900FFA7 ED9BAFAE 70964E34 DC7FB98F
IRngDriver.class (Version 15.5.12.1)	A70294AC E827D2D8 EE69535D 8776586D	68E70ADE 00EB0B8F 84882E54 848AD0D0 A2EBB88F
NoiseBufferHelper.class (Version 15.5.12.1)	A6F897DD 5622416F 592E591F 377D791B	62B94F4C EFFBC076 6CC22B19 0E98339C 939B8DEE
PTMetrics.class (Version 15.5.12.1)	22088108 A329BAAA DAAC0804 F5DAD678	68C5339D D17B9C60 DA7AF50C BB87E643 66772ABF
PtTelnetClient.class (Version 15.5.12.1)	094C58F4 9B3DC292 F6C49949 16CAB9DA	AFBD7147 F3CE9905 8021774C 06E4C4D2 929E3E20
RandomBatch.class (Version 15.5.12.1)	53410EC0 B6A93C31 B993EDB4 0D52336A	2DFE3BC4 DCD85488 B9071595 9129CD38 79F03A04
RandomBuffer\$1.class (Version 15.5.12.1)	DA5F7BC5 09F6D8AC C7A09054 7826239D	5EDB854D 79390C00 987426D1 FA307526 40BC84C9
RandomBuffer\$2.class (Version 15.5.12.1)	79DA7BB3 2C1949EC 65243DC7 48522298	C1A5123E D93E37DC 963CD47F ADE9C068 B937D572

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Software Product Details

Playtech Casino RNG (continued)

File Name	MD5 Checksum	SHA-1 Checksum
RandomBuffer.class (Version 15.5.12.1)	5EB1C30C BC12C09C 5693ECC8 B626DEE3	295D8CF5 7FFD3E1F 211D680D DC1D7E08 24D5E77B
RandomProvider.class (Version 15.5.12.1)	0B25B527 B15C56EC AD88DF9B 3DA16AFB	DA029C3C 791D7D93 2E0C8FF2 A295A725 495E02D9
RandomReader.class (Version 15.5.12.1)	F0FEC136 076646E9 B659F8A6 0394F750	8C2E5F91 38F8EE4D E42A1BE6 C8794528 242DA3DA
RandomReaderImpl.class (Version 15.5.12.1)	C2B2104F AE35A53D 7CAC38A2 184B58BD	D0BAB176 330C916F 7D8B8EF5 E65E1C09 0EAF94C5
RandomX.class (Version 15.5.12.1)	2D629A48 6B527F09 CFA79082 553BEC31	66293BA9 F6AD140C 9E71A076 D0A906DE 63BBB30A
RandomXImpl.class (Version 15.5.12.1)	318C625F 31D14F0B 952D5FF1 3195F531	EC034416 60509672 661B3C84 F354D718 F1592E8D
RandomXWrapper.class (Version 15.5.12.1)	E59C21BC 266D4AE0 CCF93912 B7B79B30	5DC10B5B 7966788D A5C24F76 94DE48B5 086E1FB7
RandomY.class (Version 15.5.12.1)	CA887074 CAC7C4C9 2D28F3D5 A0201644	46A218D1 F3719F85 5908DAFE CB6D6EBB E8B170A6
ReverseTelnetDriver.class (Version 15.5.12.1)	48DD9899 8076C94A 7AC8A2BB 2E44F3D0	D51B992F E87EB791 5AED2F01 3557B921 BB66A374

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Playtech Casino RNG (continued)

File Name	MD5 Checksum	SHA-1 Checksum
ReverseTelnetInterface.class (Version 15.5.12.1)	10DF072A 31552DF8 051DBFB8 D1DB7E01	43C295C7 59555DD7 1155B99F 959EF009 659946F0
RngDriver.class (Version 15.5.12.1)	C673FB34 0AD0D6C4 89F05BB1 E02BCE9C	18C6B789 6790CE8D 94361363 6A1C0BA9 F515F7CC
RngDriverException.class (Version 15.5.12.1)	E49AF808 2E1C7872 2CE32918 2E3D518E	699CBB79 71BF8C16 CBCE126E 87FB5034 15CE8E7C
RngServer.class (Version 15.5.12.1)	8D9CD309 7331A376 D7A12BD0 56F3D41E	BF8C1698 05DA287B 1E8077A3 99773DFD 7DD1BE4D
SG100Driver.class (Version 15.5.12.1)	F08DF12B B42A2BAE 4949F491 D8C23F5A	6490E0C4 AFE3A08 9240BB2D 34BA10FC E1C102D6

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Applied Tests

Product ID	Test Performed	Reference N°	Results	Additional Details
Playtech TV RNG Playtech Bingo RNG Playtech Poker RNG Playtech Casino RNG	Random Number Generator Analysis Source Code Review Jurisdictional Regulations Review	WI TL01_01 WI TL02_05 WI TL01_07	Pass Pass Pass	Internal Reference: MO-330-PTC-14-31

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Product Characteristics

Product ID	Characteristics
Playtech TV RNG Playtech Bingo RNG Playtech Poker RNG Playtech Casino RNG	These files contain the critical files corresponding to the RNG evaluation.

Tested by: Joost van 't Schip
Reviewed by: Michael Meeuwisse

Technical Evaluation authorized by:

John van Schaijk
Technical Director



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RNG Analysis

RANDOMNESS REPORT FOR THE PLAYTECH MULTI RNG EVALUATION

The intent of this analysis is to indicate that GLI Europe B.V. (GLI) has completed its evaluation of the Playtech Multi RNG Evaluation (Random Number Generator).

SECTION I – SCOPE OF TESTING

Playtech submitted the required materials to GLI in order to conduct a Random Number Generator analysis on the Playtech Multi RNG Evaluation. 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 multiple bingo games.

SECTION II – SOURCE CODE REVIEW

Playtech 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 ranges.



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RNG Analysis

SECTION III – DATA ANALYSIS

The game configuration and parameters for the data obtained and tested are listed in the tables below. GLI performed a data format check on each data set listed in order to confirm that the game parameters were correctly represented in the RNG data analyzed.

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.

Below also are listed the tests applied to each data set. For a description of the overall test methodology and a description of each test used, see *Appendix A*. The statistical testing was applied at 95%, 98% and 99% confidence levels.

SECTION III - I Bingo RNG

Data Set	Description	Range	Positions	Replacement	Draws
1	75-Ball Bingo	1-75	75	NO	59,300,000
2	80-Ball Bingo	1-80	80	NO	55,500,000
3	90-Ball Bingo	1-90	90	NO	49,100,000
4	Binary Data	0-4,294,967,295	1	N/A	3x 3,000,000

Table 1. Data Parameters

Final Outcome Distribution Test	Sets to Which Test Has Been Applied
Runs Test	1, 2, 3
Serial Correlation Test	1, 2, 3
Interplay Correlation Test	1, 2, 3
Adjacency Max-Min Test	1, 2, 3
Adjacency High-Low Test	1, 2, 3
Adjacency Blocks Test	1, 2, 3
Count of Counts Test	1, 2, 3
Coupon Collector's Test	1, 2, 3
Duplicates Test	1, 2, 3
Overlaps Test	1, 2, 3
Permutation Test	1, 2, 3
Total Distribution Test	1, 2, 3
Total Distribution by Position Test	1, 2, 3
DIEHARD Battery of Tests ¹	4

Table 2. Tests Applied

¹ Marsaglia, George. "The Marsaglia Random Number CDROM including the Diehard Battery of Tests of Randomness." Department of Statistics and Supercomputer Computations Research Institute. 1995. Florida State University. <<http://www.stat.fsu.edu/pub/diehard/>>



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SECTION III - II Poker RNG

Data Set	Description	Range	Positions	Replacement	Draws
1	Standard 52-Card Deck	0-51	52	NO	55,000,000
2	Binary Data	0-255	1	N/A	12,000,000

Table 3. Data Parameters

Final Outcome Distribution Test	Sets to Which Test Has Been Applied
Runs Test	1
Serial Correlation Test	1
Interplay Correlation Test	1
Adjacency Max-Min Test	1
Adjacency High-Low Test	1
Adjacency Blocks Test	1
Count of Counts Test	1
Coupon Collector's Test	1
Duplicates Test	1
Overlaps Test	1
Permutation Test	1
Total Distribution Test	1
Total Distribution by Position Test	1
DIEHARD Battery of Tests ¹	2

Table 4. Tests Applied

¹ Marsaglia, George. "The Marsaglia Random Number CDROM including the Diehard Battery of Tests of Randomness." Department of Statistics and Supercomputer Computations Research Institute. 1995. Florida State University. <<http://www.stat.fsu.edu/pub/diehard/>>



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SECTION III - III Casino RNG

Data Set	Data Type	Range		# of Selections	Replacement	Samples	Result
		Minimum	Maximum				
Slot Games							
1	5-reel slot	0	7	5	YES	18,751,156	PASS
2 ②	5-reel slot	0	11	5	YES	18,749,054	PASS
3 ②	5-reel slot	0	15	5	YES	17,500,182	PASS
4 ②	5-reel slot	0	23	5	YES	18,749,348	PASS
5 ②	5-reel slot	0	31	5	YES	15,000,467	PASS
6 ②	5-reel slot	0	47	5	YES	15,000,528	PASS
7 ②	5-reel slot	0	63	5	YES	10,000,325	PASS
8 ②	5-reel slot	0	95	5	YES	30,001,456	PASS
9 ②	5-reel slot	0	127	5	YES	14,999,999	PASS
10 ②	5-reel slot	0	191	5	YES	14,999,998	PASS
11 ②	5-reel slot	0	255	5	YES	14,999,999	PASS
12 ②	9-reel slot	0	122	9	YES	32,031,356	PASS
13 ②	3-reel slot	0	19	3	YES	31,250,992	PASS
Shuffles Made through Functionality in Utils Package							
14	Utils.Shuffle (bonus)	0	2	3	NO	32,899,262	PASS
15 ②	Utils.Shuffle (bonus)	0	6	7	NO	14,029,445	PASS
16 ②③	Utils.Shuffle (bingo)	0	89	90	NO	6,838,730	PASS
Calls Made for Specific Games							
17	Pick 3	1	726	3	YES	16,666,664	PASS
18 ②	Pick 4	1	200	4	YES	18,749,999	PASS
19	Dice	1	6	3	YES	32,812,264	PASS
20 ②	Double precision floating point number	0.0 (inclusive)	1.0 (exclusive)	1	N/A ①	43,750,000	PASS
21	Bonus Selection	0	2	2	YES	49,219,627	PASS
Selection of Unique Numbers by Drawing Numbers with Replacement Till Requested Amount of Unique Numbers Is Selected							
22 ②	Shuffle	0	5	at least 6	YES	6,695,965	PASS
23 ②	Shuffle	0	17	at least 18	YES	1,565,134	PASS
24 ②	Partial Shuffle	1	48	at least 6	YES	11,831,205	PASS
25 ②	Partial Shuffle	1	80	at least 20	YES	5,470,136	PASS

Table 5. Data Parameters

- ① Not applicable, because only one selection per sample was made.
- ② For each sample multiple selections were combined into single unique values for the purpose of conducting a Poisson Distribution Test.
- ③ The Adjacency Blocks Test, Adjacency Max-Min Test, Overlaps Test and Total Distribution Test were only applied to the first half of each sample.



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SECTION III - III Casino RNG (continued)

Data Set	Data Type	Range		# of Selections	Replacement	Samples	Result
		Minimum	Maximum				
Single Numbers of Slot Bonuses, Virtual Roulette, Etc.							
26	Single Number	0	4	1	N/A ①	97,657,202	PASS
27	Single Number	0	7	1	N/A ①	93,749,036	PASS
28	Single Number	0	12	1	N/A ①	91,402,991	PASS
29	Single Number	0	15	1	N/A ①	87,499,790	PASS
30	Single Number	0	23	1	N/A ①	93,747,746	PASS
31	Single Number	0	31	1	N/A ①	74,998,727	PASS
32	Single Number	0	36	1	N/A ①	86,713,736	PASS
33	Single Number	0	63	1	N/A ①	49,992,495	PASS
34	Single Number	0	95	1	N/A ①	75,007,727	PASS
35	Single Number	0	127	1	N/A ①	50,000,000	PASS
36	Single Number	0	191	1	N/A ①	49,999,997	PASS
37	Single Number	0	255	1	N/A ①	49,999,998	PASS
38	Single Number	0	999	1	N/A ①	49,999,988	PASS
39	Single Number	0	9,999	1	N/A ①	49,999,914	PASS
Shuffled Decks (Except for Video Pokers)							
40 ②③	Shuffle	0	51	52	NO	8,410,685	PASS
41 ②③	Shuffle	0	207	208	NO	1,650,046	PASS
42 ②③	Shuffle	0	311	312	NO	1,110,063	PASS
43 ②③	Shuffle	0	415	416	NO	1,139,087	PASS
Shuffle Decks for Video Pokers (Using a Separate Scaling Method)							
44 ②③	Shuffle	0	51	52	NO	2,450,980	PASS
45 ②③	Shuffle	0	53	54	NO	2,358,490	PASS
Selecting Items without Replacement (Using Same Scaling Method As Video Pokers)							
46 ②	Draws without replacement	0	33	4	NO	6,249,999	PASS
47 ②	Draws without replacement	0	51	10	NO	2,499,999	PASS
Shuffle by Sorting Random Double Precision Floating Point Numbers							
48	Shuffle	0	2	3	NO	2,083,333	PASS
Binary Data for DIEHARD Battery of Tests							
49	Binary Data	0	255	1	N/A ①	12,000,000 ④	PASS

Table 5. Data Parameters

- ① Not applicable, because only one selection per sample was made.
- ② For each sample multiple selections were combined into single unique values for the purpose of conducting a Poisson Distribution Test.
- ③ The Adjacency Blocks Test, Adjacency Max-Min Test, Overlaps Test and Total Distribution Test were only applied to the first half of each sample.
- ④ Note three sets of data containing this sample size were obtained and analyzed.



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SECTION III - III Casino RNG (continued)

Final Outcome Distribution Test	Sets To Which Test Has Been Applied
Runs Test	1-48
Serial Correlation Test	1-48
Interplay Correlation Test	1-25, 40-48
Adjacency Blocks Test	16, 24-25, 40-47
Adjacency Max-Min Test	16, 24-25, 40-47
Adjacency High-Low Test	14-16, 22-25, 40-48
Duplicates Test	1-15, 16-19, 22, 24-25, 40-47
Horizontal Coupon Collector's Test	22-23
Overlaps Test	16, 24-25, 40-47
Permutation Test	14-16, 22-25, 40-48
Poisson Distribution Test	2-13, 15-16, 18, 20, 23-25, 38-47
Total Distribution Test	1-13, 16-21, 24-47
Total Distribution By Columns Test	1-19, 21-25, 40-48
Vertical Coupon Collector's Test	1-6, 13-15, 19-23, 26-31, 46-48
Weighted Chi Square Test	19
DIEHARD Battery of Tests ¹	49

Table 6. Tests Applied

SECTION III - IV TV RNG

Data Set	Description	Range	Positions	Replacement	Draws
1	Single Zero Roulette	0-36	1	N/A	39,000,000
2	Binary Data	0-255	1	N/A	12,000,000

Table 7. Data Parameters

Final Outcome Distribution Test	Sets to Which Test Has Been Applied
Runs Test	1
Serial Correlation Test	1
Coupon Collector's Test	1
Total Distribution Test	1
DIEHARD Battery of Tests ¹	2

Table 8. Tests Applied

¹ Marsaglia, George. "The Marsaglia Random Number CDROM including the Diehard Battery of Tests of Randomness." Department of Statistics and Supercomputer Computations Research Institute. 1995. Florida State University. <<http://www.stat.fsu.edu/pub/diehard/>>



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SECTION III - V Conclusion

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

SECTION IV - SUMMARY

Overall Evaluation of the Random Number Generator

GLI's conclusion based upon the tests applied to the Playtech Multi RNG Evaluation 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 Playtech Multi RNG Evaluation should be resubmitted to test that set of parameters.



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APPENDIX A: Test Description

A.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*.

A.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.

A.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.

A.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.

A.5 Tests. Some tests are only applicable to certain types of data. Some tests may be applied only to a portion of the data.



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Runs Test:

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 Test:

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.

Interplay Correlation Test:

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.

Adjacency Max-Min Test:

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 of 7 and the minimum value of 2.

Adjacency High-Low Test:

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.

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Adjacency Blocks Test:

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.

1, 2, 4, 5, 6, 9

The resulting statistic would be 3.

Coupon Collector's Test:

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 Test:

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.



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Overlaps Test:

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 Test:

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.

Count of Counts Test:

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.

Total Distribution Test:

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 Test:

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.



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