Stader Labs

MaticX

Smart Contract Audit
Final Report

April 25, 2022

This audit does not provide a security or correctness guarantee of the audited smart contract. Securing smart contracts is a multistep process, therefore running a bug bounty program as a complement to this audit is strongly recommended.

Introduction

1. About Stader Labs

Stader is building the key staking middleware infrastructure layer for multiple PoS networks that will power the above staking-related opportunities while solving the key challenges. We are taking an extremely modular approach to building our contracts so third parties can leverage our components to build several staking solutions on top of it.

In the short term, Stader is building native staking smart contracts across multiple chains including Terra, and Solana, among others, and building an economic ecosystem to grow and develop solutions like YFI-style farming with rewards, launchpads, gaming with rewards, liquid staking solutions, and more.

In the long term, Stader is focused on unlocking the platform approach and nurturing third parties to develop several staking-related applications on top of Stader infrastructure.

Visit https://staderlabs.com/ to know more about it.

2. About ImmuneBytes

ImmuneBytes is a security start-up to provides professional services in the blockchain space. The team has hands-on experience in conducting smart contract audits, penetration testing, and security consulting. ImmuneBytes's security auditors have worked on various A-league projects and have a great understanding of DeFi projects like AAVE, Compound, 0x Protocol, Uniswap, and dydx.

The team has been able to secure 105+ blockchain projects by providing security services on different frameworks. ImmuneBytes team helps start-ups with a detailed analysis of the system ensuring security and managing the overall project.

Visit http://immunebytes.com/ to know more about the services.

Documentation Details

The Stader Labs team has provided the following doc for the purpose of audit:

1. https://staderlabs-docs.s3.amazonaws.com/Stader_Litepaper.pdf
2. https://github.com/stader-labs/maticX#readme

Audit Process & Methodology

ImmuneBytes team has performed thorough testing of the project starting with analyzing the code design patterns in which we reviewed the smart contract architecture to ensure it is structured and safe use of third-party smart contracts and libraries.

Our team then performed a formal line-by-line inspection of the Smart Contract in order to find any potential issues like Signature Replay Attacks, Unchecked External Calls, External Contract Referencing, Variable Shadowing, Race conditions, Transaction-ordering dependence, timestamp dependence, DoS attacks, and others.

In the Unit testing phase, we run unit tests written by the developer in order to verify the functions work as intended. In Automated Testing, we tested the Smart Contract with our in-house developed tools to identify vulnerabilities and security flaws.

The code was audited by a team of independent auditors which includes -

1. Testing the functionality of the Smart Contract to determine proper logic has been followed throughout.
2. Analyzing the complexity of the code by thorough, manual review of the code, line-by-line.
3. Deploying the code on testnet using multiple clients to run live tests.
4. Analyzing failure preparations to check how the Smart Contract performs in case of bugs and vulnerabilities.
5. Checking whether all the libraries used in the code are on the latest version.
6. Analyzing the security of the on-chain data.

Audit Details

- Project Name: Stader Labs
- Contracts Name: MaticX.sol, ValidatorRegistry.sol
- Languages: Solidity(Smart contract), Typescript (Unit Testing)
- Github commits for initial audit: 85023fa73a1325d0794dd3097a7efcbad72379bd
- Github commits for final audit: 8f914608ae40fdb35cfae281ff6c1dda9943b632
- Platforms and Tools: Remix IDE, Truffle, Truffle Team, Ganache, Solhint, VScode, Contract Library, Slither, SmartCheck

This audit does not provide a security or correctness guarantee of the audited smart contract. Securing smart contracts is a multistep process, therefore running a bug bounty program as a complement to this audit is strongly recommended.

Audit Goals

The focus of the audit was to verify that the smart contract system is secure, resilient, and working according to its specifications. The audit activities can be grouped into the following three categories:

1. Security: Identifying security-related issues within each contract and within the system of contracts.
2. Sound Architecture: Evaluation of the architecture of this system through the lens of established smart contract best practices and general software best practices.
3. Code Correctness and Quality: A full review of the contract source code. The primary areas of focus include
    a. Correctness
    b. Readability
    c. Sections of code with high complexity
    d. Quantity and quality of test coverage

Security Level Reference

Every issue in this report were assigned a severity level from the following:

High severity issues will bring problems and should be fixed.

Medium severity issues could potentially bring problems and should eventually be fixed.

Low severity issues are minor details and warnings that can remain unfixed but would be better fixed at some point in the future.

Issues	High	Medium	Low
Open	-	-	-
Closed	1	1	3

High Severity Issues

1. **Missing Authentication**
   Contract: Missing implementation of contracts (state Manager and Validator share)

   Description:
   As there are external calls to the missing contracts so the contract methods which are dependent on external calls will fail.

   Recommendation:
   Add missing implementation

   Status: Acknowledged

   Note by the team:
   Both stakeManager and validatorShare contracts are implemented and deployed by Polygon. We only use the interface contract to interact with it.

Medium Severity Issues

1. **Contract:**
   MaticX.sol

   Description:
   The reentrancy guard is missing in the MaticX.requestWithdraw.

   The state variable is written after the external call of validatorRegistry.setLastWithdrawnValidatorId.

   Recommendation:
   Create or Import a nonRentrancy guard from OpenZeppelin and apply it to the method.

   Status: Closed

   Note by the team:
   It is calling _burn function after the validatorRegistry.setLastWithdrawnValidatorId function call and validatorRegistry contract is our own contract. We can add reentrancy guard which will increase our gas cost but we don't see an issue unless our manager role gets hacked and the hacker changes the validatorRegistry contract address which itself is a separate concern. Please give us more details on reproducing this issue.

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Low Severity Issues

1. **Contract:**
   MaticX.sol

   Description:
   The rescue function for the by mistake sent funds is missing in the contract.

   If a user sends the funds by mistake to the contract then there is no way to pull the funds out by the admin and give it back to the user.

   Recommendation:
   We recommend a rescue funds method which is only operated by Admin.

   Status: Acknowledged

   Note by the team:
   As of now we believe it is a user fault that is similar to sending tokens to a wrong address and is a nice to have feature which can be included later when it becomes a major issue.

2. **Gas optimizations**
   Contract: MaticX.sol, ValidatorRegistry.sol

   Description:
   In for loop on line 186 (MaticX) and 111 (Validator Registry) the .length is calculated again and again in the for loop which will use a SLOAD operation on each iteration

   Recommendation:
   We recommend calculating the length and store it in a variable and use that variable in the food loop iteration.

   Status: Closed

   Amended: Issue was fixed by the **Stader Labs** team and is no longer present in commit 8f914608ae40fdb35cfae281ff6c1dda9943b632

This audit does not provide a security or correctness guarantee of the audited smart contract. Securing smart contracts is a multistep process, therefore running a bug bounty program as a complement to this audit is strongly recommended.

3. **Address zero check missing**
   Contract: MaticX.sol, ValidatorRegistry.sol

   Description:
   Zero check is missing in the input parameters.

   functions : MaticX.initialize, MaticX.setTreasuryAddress, ValidatorRegistry.initialize, MaticX.setValidatorRegistry, ValidatorRegistry.setMaticX,

   Recommendation:
   We recommend including zero check.

   Status: Acknowledged

   Note by the team:
   Since we can recall this functions if we were to mistakenly set it to address(0), we believe it is not worth adding an additional check for it.

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Recommendation / Informational

1. **Log emit missing**
   Contract: MaticX.sol

   Description:
   Whenever the state of the contract gets changed then their event should be admitted.
   Some functions are missing the emitting of logs.

   For eg: setValidatorRegistry, setVersion, setTreasury, setFees, setMaticX, setVersion

   Recommendation:
   At the time of state change events should be emitted properly.

   Status: Closed

   Amended: Issue was fixed by the **Stader Labs** team and is no longer present in commit 8f914608ae40fdb35cfae281ff6c1dda9943b632

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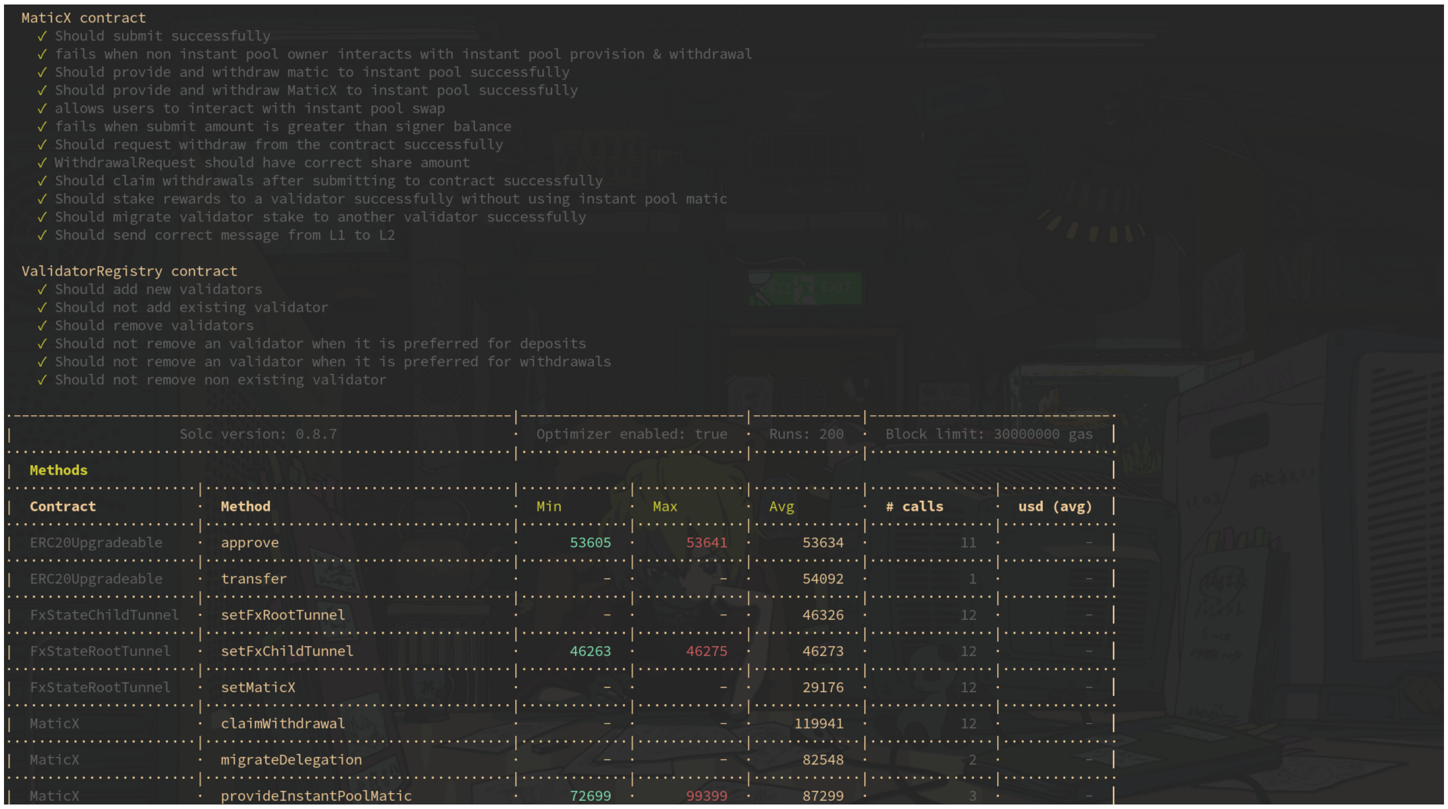
Unit Tests



```
MaticX contract
  ✓ Should submit successfully
  ✓ fails when non instant pool owner interacts with instant pool provision & withdrawal
  ✓ Should provide and withdraw matic to instant pool successfully
  ✓ Should provide and withdraw MaticX to instant pool successfully
  ✓ allows users to interact with instant pool swap
  ✓ fails when submit amount is greater than signer balance
  ✓ Should request withdraw from the contract successfully
  ✓ WithdrawalRequest should have correct share amount
  ✓ Should claim withdrawals after submitting to contract successfully
  ✓ Should stake rewards to a validator successfully without using instant pool matic
  ✓ Should migrate validator stake to another validator successfully
  ✓ Should send correct message from L1 to L2

ValidatorRegistry contract
  ✓ Should add new validators
  ✓ Should not add existing validator
  ✓ Should remove validators
  ✓ Should not remove an validator when it is preferred for deposits
  ✓ Should not remove an validator when it is preferred for withdrawals
  ✓ Should not remove non existing validator

·-----------------------------------------------------------|---------------------------|-------------|-----------------------------·
|                Solc version: 0.8.7                        ·  Optimizer enabled: true  ·  Runs: 200  ·  Block limit: 30000000 gas  │
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|  Methods                                                                                                                       │
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|  Contract            ·  Method                            ·  Min        ·  Max        ·  Avg        ·  # calls      ·  usd (avg)  │
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|  ERC20Upgradeable    ·  approve                           ·      53605  ·      53641  ·      53634  ·           11  ·          -  │
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|  ERC20Upgradeable    ·  transfer                          ·          -  ·          -  ·      54092  ·            1  ·          -  │
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|  FxStateChildTunnel  ·  setFxRootTunnel                   ·          -  ·          -  ·      46326  ·           12  ·          -  │
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|  FxStateRootTunnel   ·  setFxChildTunnel                  ·      46263  ·      46275  ·      46273  ·           12  ·          -  │
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|  FxStateRootTunnel   ·  setMaticX                         ·          -  ·          -  ·      29176  ·           12  ·          -  │
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|  MaticX              ·  claimWithdrawal                   ·          -  ·          -  ·     119941  ·           12  ·          -  │
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|  MaticX              ·  migrateDelegation                 ·          -  ·          -  ·      82548  ·            2  ·          -  │
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|  MaticX              ·  provideInstantPoolMatic           ·      72699  ·      99399  ·      87299  ·            3  ·          -  │
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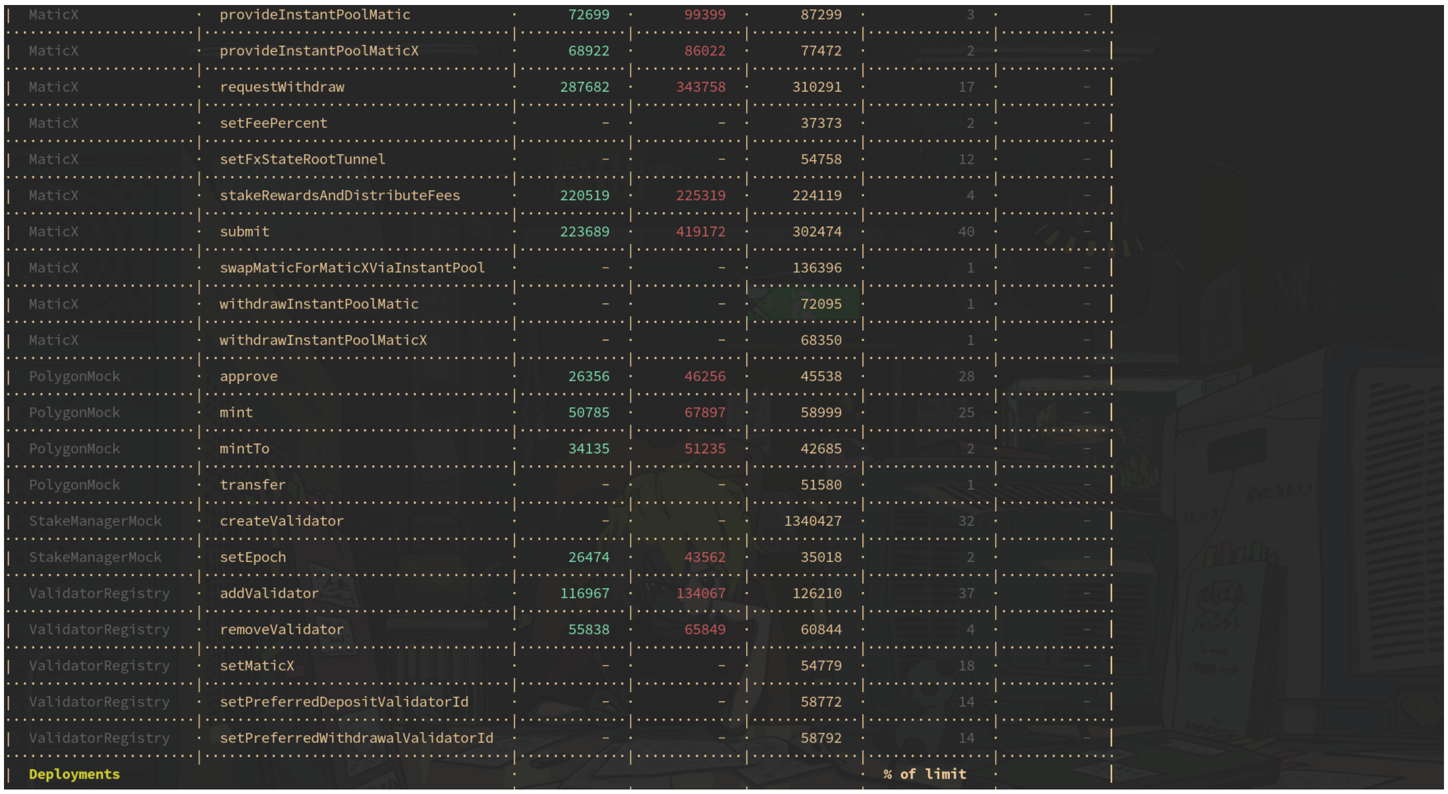

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|  MaticX             ·  provideInstantPoolMatic             ·      72699  ·      99399  ·      87299  ·          3  ·          -  |
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|  MaticX             ·  provideInstantPoolMaticX            ·      68922  ·      86022  ·      77472  ·          2  ·          -  |
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|  MaticX             ·  requestWithdraw                     ·     287682  ·     343758  ·     310291  ·         17  ·          -  |
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|  MaticX             ·  setFeePercent                       ·          -  ·          -  ·      37373  ·          2  ·          -  |
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|  MaticX             ·  setFxStateRootTunnel                ·          -  ·          -  ·      54758  ·         12  ·          -  |
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|  MaticX             ·  stakeRewardsAndDistributeFees       ·     220519  ·     225319  ·     224119  ·          4  ·          -  |
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|  MaticX             ·  submit                              ·     223689  ·     419172  ·     302474  ·         40  ·          -  |
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|  MaticX             ·  swapMaticForMaticXViaInstantPool    ·          -  ·          -  ·     136396  ·          1  ·          -  |
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|  MaticX             ·  withdrawInstantPoolMatic            ·          -  ·          -  ·      72095  ·          1  ·          -  |
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|  MaticX             ·  withdrawInstantPoolMaticX           ·          -  ·          -  ·      68350  ·          1  ·          -  |
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|  PolygonMock        ·  approve                             ·      26356  ·      46256  ·      45538  ·         28  ·          -  |
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|  PolygonMock        ·  mint                                ·      50785  ·      67897  ·      58999  ·         25  ·          -  |
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|  PolygonMock        ·  mintTo                              ·      34135  ·      51235  ·      42685  ·          2  ·          -  |
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|  PolygonMock        ·  transfer                            ·          -  ·          -  ·      51580  ·          1  ·          -  |
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|  StakeManagerMock   ·  createValidator                     ·          -  ·          -  ·    1340427  ·         32  ·          -  |
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|  StakeManagerMock   ·  setEpoch                            ·      26474  ·      43562  ·      35018  ·          2  ·          -  |
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|  ValidatorRegistry  ·  addValidator                        ·     116967  ·     134067  ·     126210  ·         37  ·          -  |
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|  ValidatorRegistry  ·  removeValidator                     ·      55838  ·      65849  ·      60844  ·          4  ·          -  |
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|  ValidatorRegistry  ·  setMaticX                           ·          -  ·          -  ·      54779  ·         18  ·          -  |
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|  ValidatorRegistry  ·  setPreferredDepositValidatorId      ·          -  ·          -  ·      58772  ·         14  ·          -  |
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|  ValidatorRegistry  ·  setPreferredWithdrawalValidatorId   ·          -  ·          -  ·      58792  ·         14  ·          -  |
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|  Deployments                                               ·                                         ·  % of limit   ·             |
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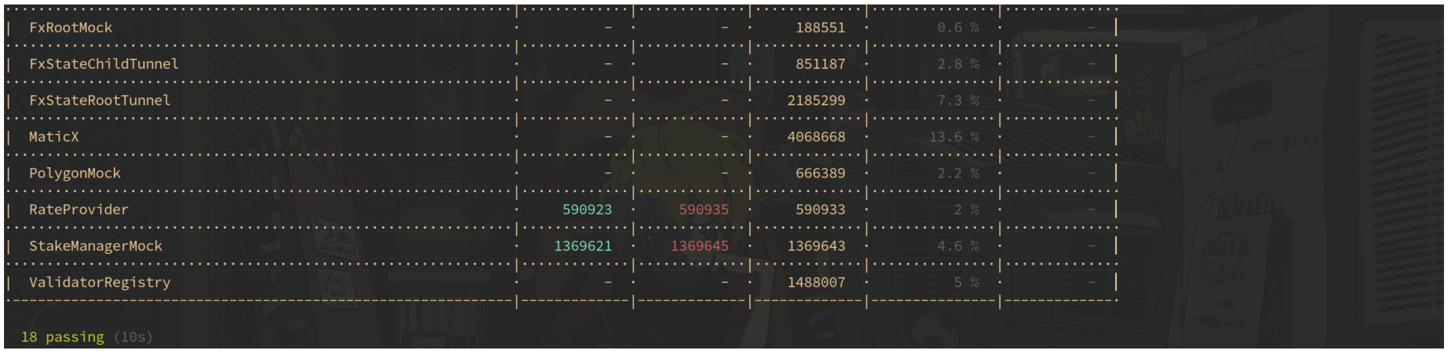

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|  FxRootMock                                                ·          -  ·          -  ·     188551  ·      0.6 %  ·          -  |
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|  FxStateChildTunnel                                        ·          -  ·          -  ·     851187  ·      2.8 %  ·          -  |
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|  FxStateRootTunnel                                         ·          -  ·          -  ·    2185299  ·      7.3 %  ·          -  |
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|  MaticX                                                    ·          -  ·          -  ·    4068668  ·     13.6 %  ·          -  |
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|  PolygonMock                                               ·          -  ·          -  ·     666389  ·      2.2 %  ·          -  |
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|  RateProvider                                              ·     590923  ·     590935  ·     590933  ·        2 %  ·          -  |
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|  StakeManagerMock                                          ·    1369621  ·    1369645  ·    1369643  ·      4.6 %  ·          -  |
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|  ValidatorRegistry                                         ·          -  ·          -  ·    1488007  ·        5 %  ·          -  |
-------------------------------------------------------------|-------------|-------------|-------------|---------------|-------------

  18 passing (10s)
```

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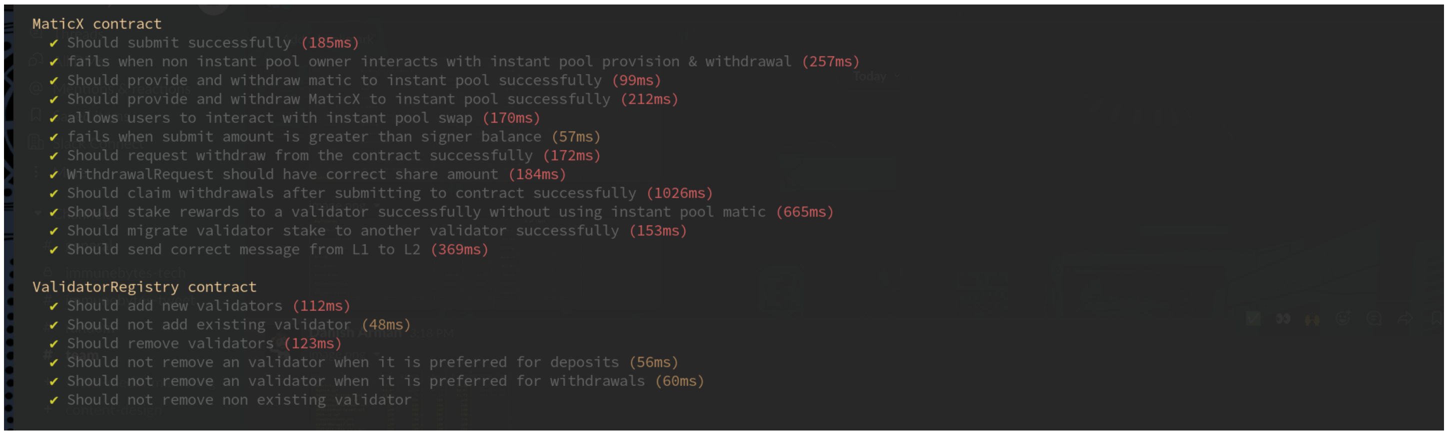
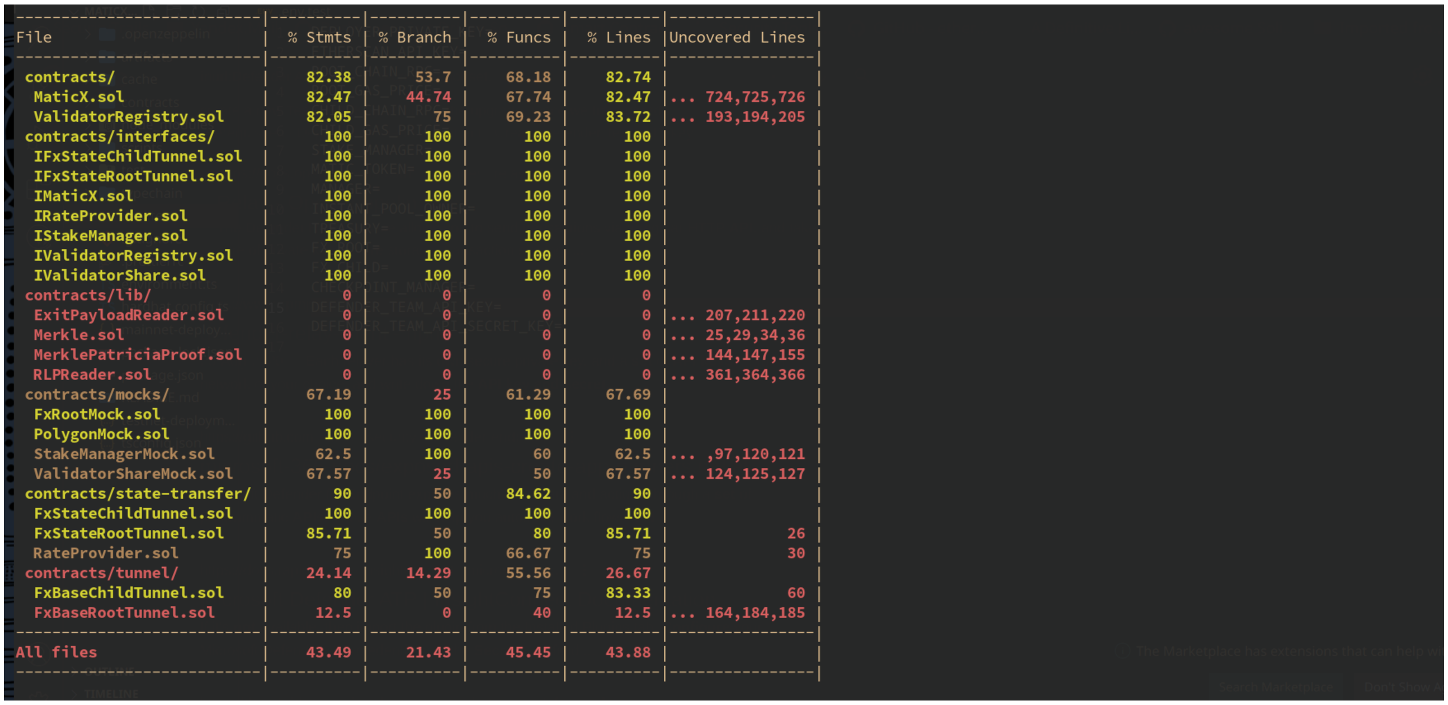
Test Coverage



```
MaticX contract
  ✔ Should submit successfully (185ms)
  ✔ fails when non instant pool owner interacts with instant pool provision & withdrawal (257ms)
  ✔ Should provide and withdraw matic to instant pool successfully (99ms)
  ✔ Should provide and withdraw MaticX to instant pool successfully (212ms)
  ✔ allows users to interact with instant pool swap (170ms)
  ✔ fails when submit amount is greater than signer balance (57ms)
  ✔ Should request withdraw from the contract successfully (172ms)
  ✔ WithdrawalRequest should have correct share amount (184ms)
  ✔ Should claim withdrawals after submitting to contract successfully (1026ms)
  ✔ Should stake rewards to a validator successfully without using instant pool matic (665ms)
  ✔ Should migrate validator stake to another validator successfully (153ms)
  ✔ Should send correct message from L1 to L2 (369ms)

ValidatorRegistry contract
  ✔ Should add new validators (112ms)
  ✔ Should not add existing validator (48ms)
  ✔ Should remove validators (123ms)
  ✔ Should not remove an validator when it is preferred for deposits (56ms)
  ✔ Should not remove an validator when it is preferred for withdrawals (60ms)
  ✔ Should not remove non existing validator
```

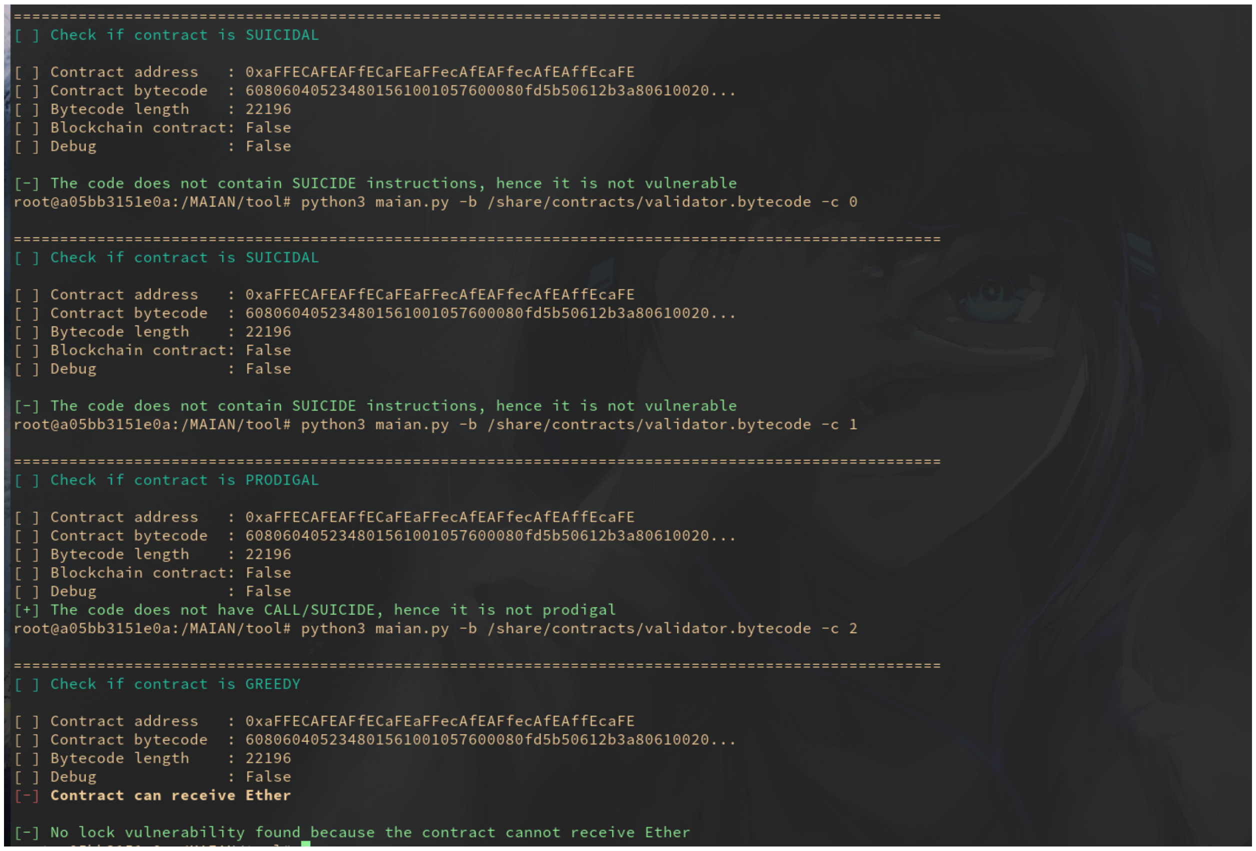


```
----------------------------|----------|----------|----------|----------|----------------|
File                        |  % Stmts | % Branch |  % Funcs |  % Lines |Uncovered Lines |
----------------------------|----------|----------|----------|----------|----------------|
 contracts/                 |    82.38 |     53.7 |    68.18 |    82.74 |                |
  MaticX.sol                |    82.47 |    44.74 |    67.74 |    82.47 |... 724,725,726 |
  ValidatorRegistry.sol     |    82.05 |       75 |    69.23 |    83.72 |... 193,194,205 |
 contracts/interfaces/      |      100 |      100 |      100 |      100 |                |
  IFxStateChildTunnel.sol   |      100 |      100 |      100 |      100 |                |
  IFxStateRootTunnel.sol    |      100 |      100 |      100 |      100 |                |
  IMaticX.sol               |      100 |      100 |      100 |      100 |                |
  IRateProvider.sol         |      100 |      100 |      100 |      100 |                |
  IStakeManager.sol         |      100 |      100 |      100 |      100 |                |
  IValidatorRegistry.sol    |      100 |      100 |      100 |      100 |                |
  IValidatorShare.sol       |      100 |      100 |      100 |      100 |                |
 contracts/lib/             |        0 |        0 |        0 |        0 |                |
  ExitPayloadReader.sol     |        0 |        0 |        0 |        0 |... 207,211,220 |
  Merkle.sol                |        0 |        0 |        0 |        0 |... 25,29,34,36 |
  MerklePatriciaProof.sol   |        0 |        0 |        0 |        0 |... 144,147,155 |
  RLPReader.sol             |        0 |        0 |        0 |        0 |... 361,364,366 |
 contracts/mocks/           |    67.19 |       25 |    61.29 |    67.69 |                |
  FxRootMock.sol            |      100 |      100 |      100 |      100 |                |
  PolygonMock.sol           |      100 |      100 |      100 |      100 |                |
  StakeManagerMock.sol      |     62.5 |      100 |       60 |     62.5 |... ,97,120,121 |
  ValidatorShareMock.sol    |    67.57 |       25 |       50 |    67.57 |... 124,125,127 |
 contracts/state-transfer/  |       90 |       50 |    84.62 |       90 |                |
  FxStateChildTunnel.sol    |      100 |      100 |      100 |      100 |                |
  FxStateRootTunnel.sol     |    85.71 |       50 |       80 |    85.71 |             26 |
  RateProvider.sol          |       75 |      100 |    66.67 |       75 |             30 |
 contracts/tunnel/          |    24.14 |    14.29 |    55.56 |    26.67 |                |
  FxBaseChildTunnel.sol     |       80 |       50 |       75 |    83.33 |             60 |
  FxBaseRootTunnel.sol      |     12.5 |        0 |       40 |     12.5 |... 164,184,185 |
----------------------------|----------|----------|----------|----------|----------------|
All files                   |    43.49 |    21.43 |    45.45 |    43.88 |                |
----------------------------|----------|----------|----------|----------|----------------|
```

This audit does not provide a security or correctness guarantee of the audited smart contract. Securing smart contracts is a multistep process, therefore running a bug bounty program as a complement to this audit is strongly recommended.

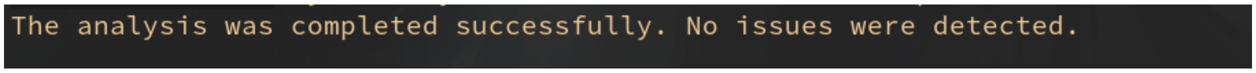
Automated Audit Result

Maian



```
====================================================================================================
[ ] Check if contract is SUICIDAL

[ ] Contract address   : 0xaFFECAFEAFfECaFEaFFecAfEAFfecAfEAffEcaFE
[ ] Contract bytecode  : 608060405234801561001057600080fd5b50612b3a80610020...
[ ] Bytecode length    : 22196
[ ] Blockchain contract: False
[ ] Debug              : False

[-] The code does not contain SUICIDE instructions, hence it is not vulnerable
root@a05bb3151e0a:/MAIAN/tool# python3 maian.py -b /share/contracts/validator.bytecode -c 0

====================================================================================================
[ ] Check if contract is SUICIDAL

[ ] Contract address   : 0xaFFECAFEAFfECaFEaFFecAfEAFfecAfEAffEcaFE
[ ] Contract bytecode  : 608060405234801561001057600080fd5b50612b3a80610020...
[ ] Bytecode length    : 22196
[ ] Blockchain contract: False
[ ] Debug              : False

[-] The code does not contain SUICIDE instructions, hence it is not vulnerable
root@a05bb3151e0a:/MAIAN/tool# python3 maian.py -b /share/contracts/validator.bytecode -c 1

====================================================================================================
[ ] Check if contract is PRODIGAL

[ ] Contract address   : 0xaFFECAFEAFfECaFEaFFecAfEAFfecAfEAffEcaFE
[ ] Contract bytecode  : 608060405234801561001057600080fd5b50612b3a80610020...
[ ] Bytecode length    : 22196
[ ] Blockchain contract: False
[ ] Debug              : False
[+] The code does not have CALL/SUICIDE, hence it is not prodigal
root@a05bb3151e0a:/MAIAN/tool# python3 maian.py -b /share/contracts/validator.bytecode -c 2

====================================================================================================
[ ] Check if contract is GREEDY

[ ] Contract address   : 0xaFFECAFEAFfECaFEaFFecAfEAFfecAfEAffEcaFE
[ ] Contract bytecode  : 608060405234801561001057600080fd5b50612b3a80610020...
[ ] Bytecode length    : 22196
[ ] Debug              : False
[-] Contract can receive Ether

[-] No lock vulnerability found because the contract cannot receive Ether
```

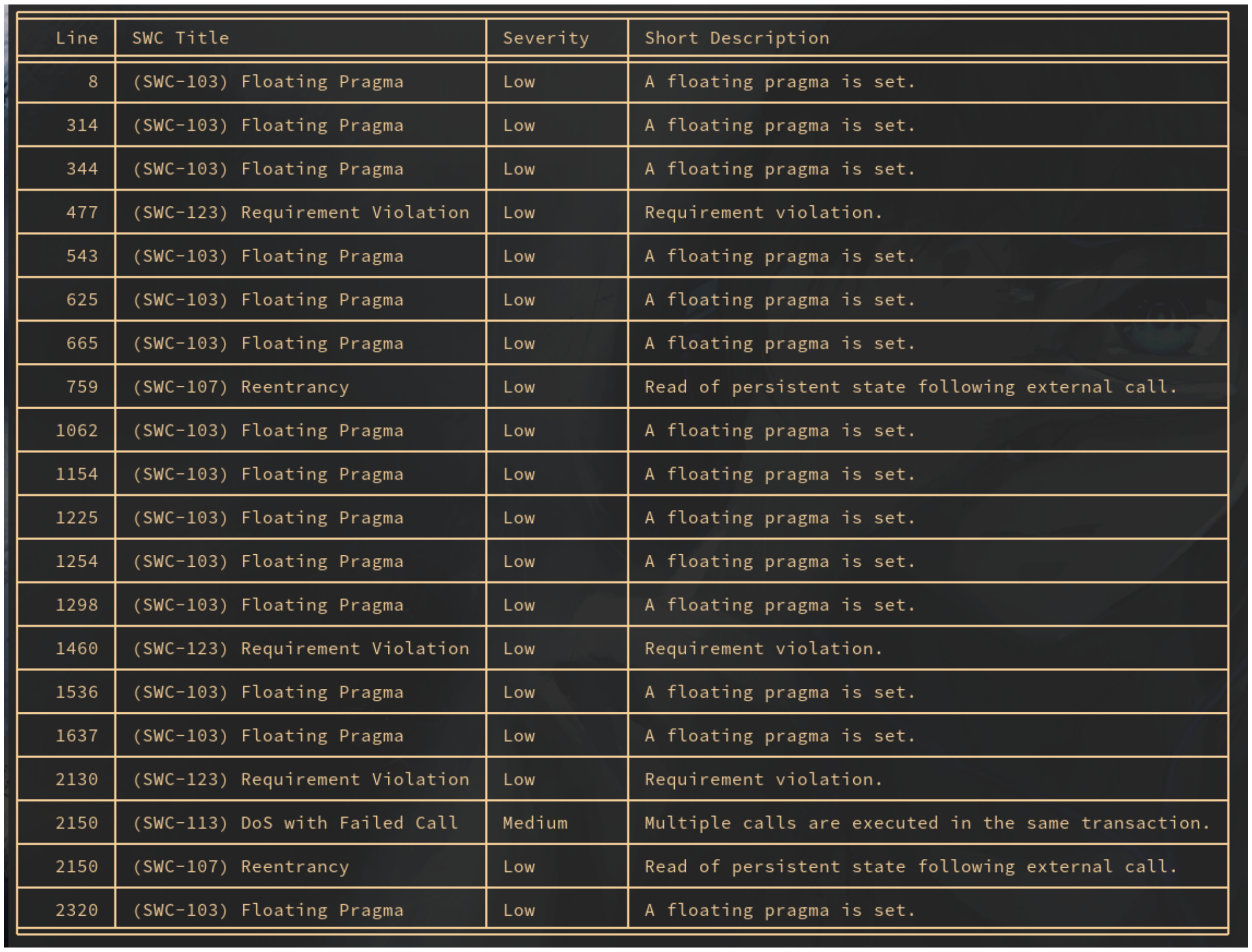
Mythril



```
The analysis was completed successfully. No issues were detected.
```

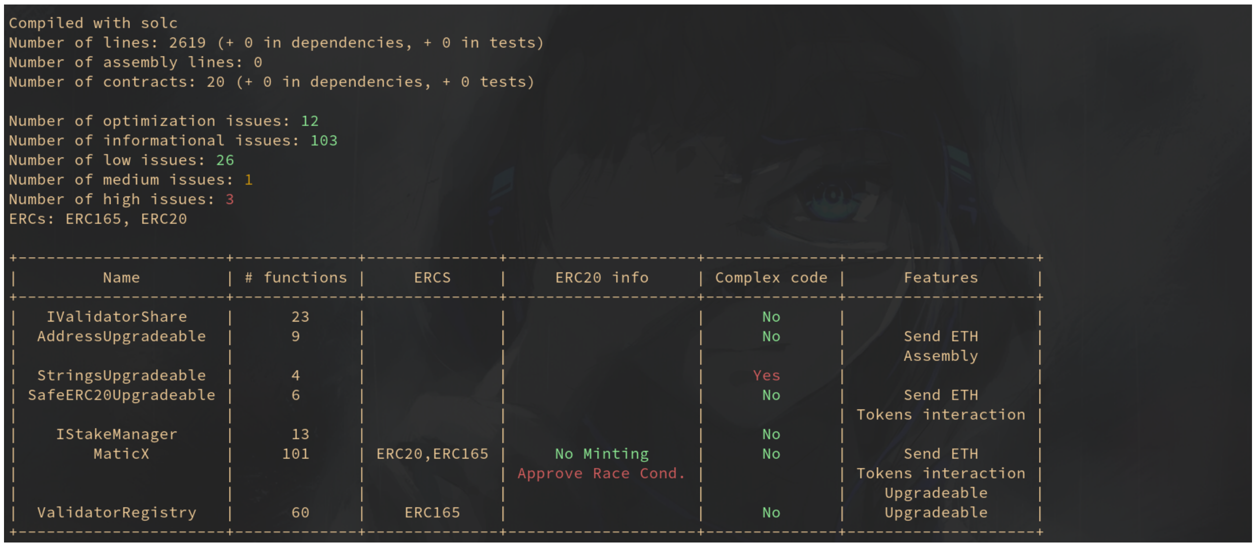
This audit does not provide a security or correctness guarantee of the audited smart contract. Securing smart contracts is a multistep process, therefore running a bug bounty program as a complement to this audit is strongly recommended.

MythX



Line	SWC Title	Severity	Short Description
8	(SWC-103) Floating Pragma	Low	A floating pragma is set.
314	(SWC-103) Floating Pragma	Low	A floating pragma is set.
344	(SWC-103) Floating Pragma	Low	A floating pragma is set.
477	(SWC-123) Requirement Violation	Low	Requirement violation.
543	(SWC-103) Floating Pragma	Low	A floating pragma is set.
625	(SWC-103) Floating Pragma	Low	A floating pragma is set.
665	(SWC-103) Floating Pragma	Low	A floating pragma is set.
759	(SWC-107) Reentrancy	Low	Read of persistent state following external call.
1062	(SWC-103) Floating Pragma	Low	A floating pragma is set.
1154	(SWC-103) Floating Pragma	Low	A floating pragma is set.
1225	(SWC-103) Floating Pragma	Low	A floating pragma is set.
1254	(SWC-103) Floating Pragma	Low	A floating pragma is set.
1298	(SWC-103) Floating Pragma	Low	A floating pragma is set.
1460	(SWC-123) Requirement Violation	Low	Requirement violation.
1536	(SWC-103) Floating Pragma	Low	A floating pragma is set.
1637	(SWC-103) Floating Pragma	Low	A floating pragma is set.
2130	(SWC-123) Requirement Violation	Low	Requirement violation.
2150	(SWC-113) DoS with Failed Call	Medium	Multiple calls are executed in the same transaction.
2150	(SWC-107) Reentrancy	Low	Read of persistent state following external call.
2320	(SWC-103) Floating Pragma	Low	A floating pragma is set.

Slither



```
Compiled with solc
Number of lines: 2619 (+ 0 in dependencies, + 0 in tests)
Number of assembly lines: 0
Number of contracts: 20 (+ 0 in dependencies, + 0 tests)

Number of optimization issues: 12
Number of informational issues: 103
Number of low issues: 26
Number of medium issues: 1
Number of high issues: 3
ERCs: ERC165, ERC20

+---------------------+-------------+-------------+--------------------+--------------+--------------------+
|        Name         | # functions |    ERCS     |     ERC20 info     | Complex code |      Features      |
+---------------------+-------------+-------------+--------------------+--------------+--------------------+
|   IValidatorShare   |     23      |             |                    |      No      |                    |
|  AddressUpgradeable |      9      |             |                    |      No      |      Send ETH      |
|                     |             |             |                    |              |      Assembly      |
|  StringsUpgradeable |      4      |             |                    |     Yes      |                    |
| SafeERC20Upgradeable|      6      |             |                    |      No      |      Send ETH      |
|                     |             |             |                    |              | Tokens interaction |
|    IStakeManager    |     13      |             |                    |      No      |                    |
|        MaticX       |     101     | ERC20,ERC165|     No Minting     |      No      |      Send ETH      |
|                     |             |             | Approve Race Cond. |              | Tokens interaction |
|                     |             |             |                    |              |    Upgradeable     |
|  ValidatorRegistry  |     60      |    ERC165   |                    |      No      |    Upgradeable     |
+---------------------+-------------+-------------+--------------------+--------------+--------------------+
```

Concluding Remarks

While conducting the audits of the Stader Labs smart contracts, it was observed that the contracts contain High, Medium, and Low severity issues.

Our auditors suggest that High, Medium, and Low severity issues should be resolved by the developers. The recommendations given will improve the operations of the smart contract.

Note: ***Stader Labs team has Acknowledged/fixed the issues based on the auditor's recommendation. The bitcciCash does not have any issues present in the contract.***

Disclaimer

ImmuneBytes's audit does not provide a security or correctness guarantee of the audited smart contract. Securing smart contracts is a multistep process, therefore running a bug bounty program as a complement to this audit is strongly recommended.

Our team does not endorse the Stader Labs platform or its product nor this audit is investment advice.
Notes:

- Please make sure contracts deployed on the mainnet are the ones audited.
- Check for the code refactor by the team on critical issues.

ImmuneBytes