QuillAudits

Audit Report
December, 2024

For

cSIGMA

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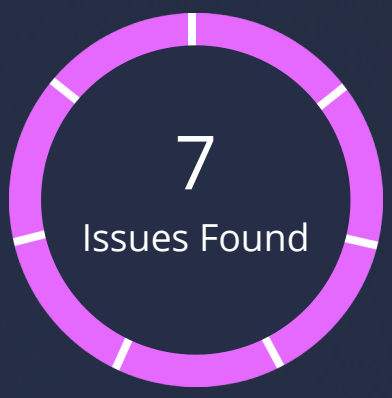
Executive Summary

Project Name	cSigma
Project URL	https://csigma.finance/
Overview	The system is a comprehensive financial protocol designed for real-world asset tokenization, fund management, and staking. It features modular contracts for creating and managing investment pools, staking assets, and distributing rewards. The system leverages AccessControlUpgradeable for role management and supports upgradeable contracts for flexibility and future enhancements. Its functionality includes secure asset deposits, governance-driven configuration, and user-focused operations like staking, unstaking, and reward withdrawals.
Audit Scope	The Scope of the Audit is to Analyse the Security, Code Quality and Correctness of csigma Contracts
Contracts In-Scope	https://github.com/csigma-labs/upgradeable-proxy-contracts/tree/release-v2.1/contracts/v2 Factory Pool Staking pool Staking pool extension Fund manager
Language	Solidity
Blockchain	Ethereum, Arbitrum
Method	Manual Analysis, Functional Testing, Automated Testing
First Review	7th November 2024 - 28th November 2024
Updated Code Received	4th December 2024
Second Review	4th December 2024 - 5th December 2024
Fixed In	https://github.com/csigma-labs/upgradeable-proxy-contracts/commit/9ce3427f5d9c86a9e635bab25bc9ad7715040d84

Number of Security Issues per Severity



High
Medium
Low
Informational

	High	Medium	Low	Informational
Open Issues	0	0	0	0
Acknowledged Issues	0	0	0	4
Partially Resolved Issues	0	0	0	0
Resolved Issues	0	0	0	3

Checked Vulnerabilities

- Access Management
- Arbitrary write to storage
- Centralization of control
- Ether theft
- Improper or missing events
- Logical issues and flaws
- Arithmetic Correctness
- Race conditions/front running
- SWC Registry
- Re-entrancy
- Timestamp Dependence
- Gas Limit and Loops
- Exception Disorder
- Gasless Send
- Use of tx.origin
- Malicious libraries
- Compiler version not fixed
- Address hardcoded
- Divide before multiply
- Integer overflow/underflow
- ERC's conformance
- Dangerous strict equalities
- Tautology or contradiction
- Return values of low-level calls
- Missing Zero Address Validation
- Private modifier
- Revert/require functions
- Multiple Sends
- Using suicide
- Using delegatecall
- Upgradeable safety
- Using throw

Checked Vulnerabilities

- Using inline assembly
- Unsafe type inference
- Style guide violation
- Implicit visibility level

Techniques and Methods

Throughout the audit of smart contracts, care was taken to ensure:

- The overall quality of code.
- Use of best practices.
- Code documentation and comments, match logic and expected behavior.
- Token distribution and calculations are as per the intended behavior mentioned in the whitepaper.
- Implementation of ERC standards.
- Efficient use of gas.
- Code is safe from re-entrancy and other vulnerabilities.

The following techniques, methods, and tools were used to review all the smart contracts.

Structural Analysis

In this step, we have analyzed the design patterns and structure of smart contracts. A thorough check was done to ensure the smart contract is structured in a way that will not result in future problems.

Static Analysis

A static Analysis of Smart Contracts was done to identify contract vulnerabilities. In this step, a series of automated tools are used to test the security of smart contracts.

Code Review / Manual Analysis

Manual Analysis or review of code was done to identify new vulnerabilities or verify the vulnerabilities found during the static analysis. Contracts were completely manually analyzed, their logic was checked and compared with the one described in the whitepaper. Besides, the results of the automated analysis were manually verified.

Gas Consumption

In this step, we have checked the behavior of smart contracts in production. Checks were done to know how much gas gets consumed and the possibilities of optimization of code to reduce gas consumption.

Tools and Platforms used for Audit

Remix IDE, Foundry, Solhint, Mythril, Slither, Solidity statistic analysis.

Types of Severity

Every issue in this report has been assigned to a severity level. There are four levels of severity, and each of them has been explained below.

High Severity Issues

A high severity issue or vulnerability means that your smart contract can be exploited. Issues on this level are critical to the smart contract's performance or functionality, and we recommend these issues be fixed before moving to a live environment.

Medium Severity Issues

The issues marked as medium severity usually arise because of errors and deficiencies in the smart contract code. Issues on this level could potentially bring problems, and they should still be fixed.

Low Severity Issues

Low-level severity issues can cause minor impact and are just warnings that can remain unfixed for now. It would be better to fix these issues at some point in the future.

Informational

These are four severity issues that indicate an improvement request, a general question, a cosmetic or documentation error, or a request for information. There is low-to-no impact.

Types of Issues

Open

Security vulnerabilities identified that must be resolved and are currently unresolved.

Resolved

These are the issues identified in the initial audit and have been successfully fixed.

Acknowledged

Vulnerabilities which have been acknowledged but are yet to be resolved.

Partially Resolved

Considerable efforts have been invested to reduce the risk/impact of the security issue, but are not completely resolved.

Informational Issues

1. Inconsistent Role Management Mechanism

Path

CsigmaV2Factory, CsigmaV2FundManager

Description

The contracts utilize AccessControlUpgradeable for role management, but some roles (PoolManager in CsigmaV2Factory, poolManager, and fundManager in CsigmaV2FundManager) use separate mechanisms. This inconsistency increases complexity and may lead to unauthorized access or mismanagement.

Recommendation

Unify all role management under AccessControlUpgradeable to standardize access checks and simplify role validation logic.

Status

Acknowledged

Csigma Team's Comment

The poolManager role operates through a separate mechanism, utilized in CSigmaV2Pool and CSigmaV2FundManager, but not in CSigmaV2Factory.

The pool manager's address can be updated directly within the pool contract. The fund manager and other future modules dynamically retrieve the pool manager's details from the pool contract.

If we were to use OpenZeppelin's AccessControlUpgradeable for managing the poolManager role, every time the pool manager address changes, we would need to revoke and reassign access across all dependent contracts. This would be inefficient and costly in our case.

Our current approach simplifies role management for the pool manager and avoids the overhead of reassigning roles, making it more practical than relying on OpenZeppelin's upgradeable access control.

2. Missing Validation for Percentage in updateNonReservePercentage

Path

contracts/v2/CsigmaV2Pool.sol

Function

updateNonReservePercentage

Description

The updateNonReservePercentage function allows setting any value for _percentage without validation. This value is used in the deposit function to calculate the portion of assets transferred to the fundManager as (assets * nonReservePercentage) / 10000. If nonReservePercentage is set to an excessively high value (e.g., greater than 10000, representing 100%), it can result in all deposited assets being transferred to the fundManager, leaving no reserves in the pool.

Recommendation

Add a validation check in updateNonReservePercentage to ensure _percentage remains within a valid range.

Status

Resolved

3. Missing Validation for pauseDuration in updatePauseDuration

Path

contracts/v2/CsigmaV2Pool.sol

Function

updatePauseDuration

Description

The updatePauseDuration function allows the admin to set an arbitrary value for pauseDuration without validation. This could result in excessively long or inappropriate pause durations, potentially causing unnecessary disruptions to the system's availability and user operations.

Recommendation

Add validation to ensure pauseDuration is within reasonable bounds.

Status

Resolved

4. Missing Event Emission in CsigmaV2Pool for Critical State Updates

Path

contracts/v2/CsigmaV2Pool.sol

Function

updateInitialDepositTime, updatePauseDuration, updatePauseStartTime, updateNonReservePercentage, updatePoolSize

Description

The CsigmaV2Pool contract lacks event emissions for several critical state-changing functions, including updateInitialDepositTime, updatePauseDuration, updatePauseStartTime, updateNonReservePercentage, and updatePoolSize. This omission reduces transparency and makes it difficult to monitor or audit changes to the pool's configuration. Without events, off-chain systems and stakeholders cannot track these updates effectively.

Recommendation

Ensure all critical actions, especially those involving state changes or administrative controls, emit appropriate events. For example, emit events for role changes, configuration updates, and fund transfers to enhance traceability and facilitate off-chain monitoring.

Status

Resolved

5. Centralization Risk in Pool Status Management

Path

contracts/v2/CsigmaV2StakingPool.sol, contracts/v2/CsigmaV2StakingPoolExtension.sol

Function

updatePoolStatus

Description

The updatePoolStatus function allows the admin to arbitrarily change the pool's status to CLOSED or PENDING, which disables key user actions like staking or unstaking. When the pool is not in an ACTIVE state, users cannot withdraw their funds, even if their assets are unlocked. This introduces a centralization risk where an admin could unintentionally or maliciously block user funds.

Recommendation

Implement additional safeguards such as:

1. Requiring a governance vote or multi-signature approval for status changes.
2. Ensuring users can always withdraw unlocked funds, regardless of the pool's status.
3. Adding a time delay to status changes, allowing users to act before the pool status is updated.

Status

Acknowledged

Csigma Team's Comment

The DEFAULT_ADMIN_ROLE, responsible for managing pool status updates, is controlled through a multi-signature (multi-sig) approval process. This setup ensures that no single entity can arbitrarily or maliciously alter the pool's status, thereby minimizing the risk of user funds being locked. Any status change requires approval from multiple trusted parties, enhancing both security and accountability. Additionally, governance rules outline clear scenarios for status updates, providing transparency to users.
Thus, the current design balances security and operational flexibility without compromising user control over their funds.

6. Missing Validation in updateMinMaxDurationAllowed

Path

contracts/v2/CsigmaV2StakingPool.sol, contracts/v2/CsigmaV2StakingPoolExtension.sol

Function

updateMinMaxDurationAllowed

Description

The updateMinMaxDurationAllowed function allows the admin to set arbitrary values for _min and _max without validation. This can result in configurations where minStakeDurationAllowed is greater than maxStakeDurationAllowed, creating invalid or contradictory staking conditions.

Recommendation

Add a validation check to ensure _min is always less than or equal to _max.

Status

Acknowledged

Csigma Team's Comment

There is no predefined minimum or maximum period for staking, allowing flexibility for future configurations. The minimum can be set to 0, and the maximum can be any value determined by the admin.

Since this is an admin-triggered function, thorough checks and due diligence are conducted before execution, reducing the likelihood of setting an incorrect value to an extremely low probability.

7. Potential DoS Risk in deployFunds with Excessive Pools

Path

contracts/v2/CsigmaV2FundManager.sol

Function

deployFunds, addPool

Description

The deployFunds function iterates through all v1Pools to distribute funds based on their allocation. If the number of pools becomes too large, this loop may exceed gas limits, causing the function to fail (DoS risk). While the total allocation is capped at 10000, there is no restriction on the number of pools that can be added. This could result in operational issues and blocked fund deployment.

Recommendation

Implement a cap on the maximum number of pools allowed in v1Pools during addPool.

Status

Acknowledged

Csigma Team's Comment

While the function currently has no hard cap on the number of pools, operational constraints, and governance controls inherently limit pool creation. Pools are segregated based on the risk profile, APR or yield, geographic region and industry, and no Master Pool will have a large number of child pools to be managed by this Fund Manager Smart Contact method. In real-world scenarios, the number of active pools managed by this function in a single call is strategically managed to remain low (typically five to seven).

In the event that pool numbers grow beyond operational thresholds, the poolManager retains the ability to dynamically manage and remove excess pools, ensuring that capital can be redeployed without disruption. This flexibility ensures seamless fund deployment regardless of pool count.

The current approach balances scalability and efficiency, and no additional storage or hard limits are necessary given the governance oversight and operational safeguards already in place.

Automated Tests

No major issues were found. Some false positive errors were reported by the tools. All the other issues have been categorized above according to their level of severity.

Closing Summary

In this report, we have considered the security of cSigma. We performed our audit according to the procedure described above.

Some issues of informational severity were found. Some suggestions, gas optimizations and best practices are also provided in order to improve the code quality and security posture.

Disclaimer

QuillAudits Smart contract security audit provides services to help identify and mitigate potential security risks in cSigma. However, it is important to understand that no security audit can guarantee complete protection against all possible security threats. QuillAudits audit reports are based on the information provided to us at the time of the audit, and we cannot guarantee the accuracy or completeness of this information. Additionally, the security landscape is constantly evolving, and new security threats may emerge after the audit has been completed.

Therefore, it is recommended that multiple audits and bug bounty programs be conducted to ensure the ongoing security of cSigma. One audit is not enough to guarantee complete protection against all possible security threats. It is important to implement proper risk management strategies and stay vigilant in monitoring your smart contracts for potential security risks.

QuillAudits cannot be held liable for any security breaches or losses that may occur subsequent to and despite using our audit services. It is the responsibility of cSigma to implement the recommendations provided in our audit reports and to take appropriate steps to mitigate potential security risks.

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1000+
Audits Completed

$30B
Secured

1M+
Lines of Code Audited

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For

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QuillAudits

Canada, India, Singapore, UAE, UK

www.quillaudits.com

audits@quillhash.com