SMART CONTRACT AUDIT REPORT

for

Forced Liquidation in Venus

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1 Introduction

Given the opportunity to review the design document and related smart contract source code of the new Forced Liquidation support in Venus, we outline in the report our systematic approach to evaluate potential security issues in the smart contract implementation, expose possible semantic inconsistencies between smart contract code and design document, and provide additional suggestions or recommendations for improvement. Our results show that the given version of smart contracts is well designed and engineered, though it can be further improved by addressing our suggestions. This document outlines our audit results.

1.1 About Forced Liquidation in Venus

The Venus protocol is designed to enable a complete algorithmic money market protocol on Binance Smart Chain (BSC). Venus enables users to utilize their cryptocurrencies by supplying collateral to the protocol that may be borrowed by pledging over-collateralized cryptocurrencies. It also features a synthetic stablecoin (VAI) that is not backed by a basket of fiat currencies but by a basket of cryptocurrencies. Venus utilizes the BSC for fast, low-cost transactions while accessing a deep network of wrapped tokens and liquidity. The new Venus Forced Liquidation feature, if enabled in one market, allows borrow positions to be liquidated even when the health rate of the involved user is greater than 1. Moreover, the close factor check would be ignored, allowing the liquidation of 100% of the debt in one transaction. The basic information of the audited feature is as follows:

Table 1.1: Basic Information of Forced Liquidation in Venus

Item	Description
Name	Venus
Website	https://venus.io/
Type	Solidity Smart Contract
Platform	Solidity
Audit Method	Whitebox
Latest Audit Report	September 16, 2023

In the following, we show the Git repository of reviewed files and the commit hash value used in this audit.

- https://github.com/VenusProtocol/venus-protocol/pull/332 (eaf564f)

1.2 About PeckShield

PeckShield Inc. [7] is a leading blockchain security company with the goal of elevating the security, privacy, and usability of current blockchain ecosystems by offering top-notch, industry-leading services and products (including the service of smart contract auditing). We are reachable at Telegram (https://t.me/peckshield), Twitter (http://twitter.com/peckshield), or Email (contact@peckshield.com).

Table 1.2: Vulnerability Severity Classification

Impact \ Likelihood	*High*	*Medium*	*Low*
High	Critical	High	Medium
Medium	High	Medium	Low
Low	Medium	Low	Low

1.3 Methodology

To standardize the evaluation, we define the following terminology based on the OWASP Risk Rating Methodology [6]:

- Likelihood represents how likely a particular vulnerability is to be uncovered and exploited in the wild;
- Impact measures the technical loss and business damage of a successful attack;
- Severity demonstrates the overall criticality of the risk.

Likelihood and impact are categorized into three ratings: *H*, *M* and *L*, i.e., *high*, *medium* and *low* respectively. Severity is determined by likelihood and impact and can be classified into four categories accordingly, i.e., *Critical*, *High*, *Medium*, *Low* shown in Table 1.2.

Table 1.3: The Full Audit Checklist

Category	Checklist Items
Basic Coding Bugs	Constructor Mismatch
	Ownership Takeover
	Redundant Fallback Function
	Overflows & Underflows
	Reentrancy
	Money-Giving Bug
	Blackhole
	Unauthorized Self-Destruct
	Revert DoS
	Unchecked External Call
	Gasless Send
	Send Instead Of Transfer
	Costly Loop
	(Unsafe) Use Of Untrusted Libraries
	(Unsafe) Use Of Predictable Variables
	Transaction Ordering Dependence
	Deprecated Uses
Semantic Consistency Checks	Semantic Consistency Checks
Advanced DeFi Scrutiny	Business Logics Review
	Functionality Checks
	Authentication Management
	Access Control & Authorization
	Oracle Security
	Digital Asset Escrow
	Kill-Switch Mechanism
	Operation Trails & Event Generation
	ERC20 Idiosyncrasies Handling
	Frontend-Contract Integration
	Deployment Consistency
	Holistic Risk Management
Additional Recommendations	Avoiding Use of Variadic Byte Array
	Using Fixed Compiler Version
	Making Visibility Level Explicit
	Making Type Inference Explicit
	Adhering To Function Declaration Strictly
	Following Other Best Practices

To evaluate the risk, we go through a checklist of items and each would be labeled with a severity category. For one check item, if our tool or analysis does not identify any issue, the contract is considered safe regarding the check item. For any discovered issue, we might further deploy contracts on our private testnet and run tests to confirm the findings. If necessary, we would additionally build a PoC to demonstrate the possibility of exploitation. The concrete list of check items is shown in Table 1.3.

In particular, we perform the audit according to the following procedure:

- Basic Coding Bugs: We first statically analyze given smart contracts with our proprietary static code analyzer for known coding bugs, and then manually verify (reject or confirm) all the issues found by our tool.

- Semantic Consistency Checks: We then manually check the logic of implemented smart contracts and compare with the description in the white paper.

- Advanced DeFi Scrutiny: We further review business logics, examine system operations, and place DeFi-related aspects under scrutiny to uncover possible pitfalls and/or bugs.

- Additional Recommendations: We also provide additional suggestions regarding the coding and development of smart contracts from the perspective of proven programming practices.

To better describe each issue we identified, we categorize the findings with Common Weakness Enumeration (CWE-699) [5], which is a community-developed list of software weakness types to better delineate and organize weaknesses around concepts frequently encountered in software development. Though some categories used in CWE-699 may not be relevant in smart contracts, we use the CWE categories in Table 1.4 to classify our findings. Moreover, in case there is an issue that may affect an active protocol that has been deployed, the public version of this report may omit such issue, but will be amended with full details right after the affected protocol is upgraded with respective fixes.

1.4 Disclaimer

Note that this security audit is not designed to replace functional tests required before any software release, and does not give any warranties on finding all possible security issues of the given smart contract(s) or blockchain software, i.e., the evaluation result does not guarantee the nonexistence of any further findings of security issues. As one audit-based assessment cannot be considered comprehensive, we always recommend proceeding with several independent audits and a public bug bounty program to ensure the security of smart contract(s). Last but not least, this security audit should not be used as investment advice.

Table 1.4: Common Weakness Enumeration (CWE) Classifications Used in This Audit

Category	Summary
Configuration	Weaknesses in this category are typically introduced during the configuration of the software.
Data Processing Issues	Weaknesses in this category are typically found in functionality that processes data.
Numeric Errors	Weaknesses in this category are related to improper calculation or conversion of numbers.
Security Features	Weaknesses in this category are concerned with topics like authentication, access control, confidentiality, cryptography, and privilege management. (Software security is not security software.)
Time and State	Weaknesses in this category are related to the improper management of time and state in an environment that supports simultaneous or near-simultaneous computation by multiple systems, processes, or threads.
Error Conditions, Return Values, Status Codes	Weaknesses in this category include weaknesses that occur if a function does not generate the correct return/status code, or if the application does not handle all possible return/status codes that could be generated by a function.
Resource Management	Weaknesses in this category are related to improper management of system resources.
Behavioral Issues	Weaknesses in this category are related to unexpected behaviors from code that an application uses.
Business Logic	Weaknesses in this category identify some of the underlying problems that commonly allow attackers to manipulate the business logic of an application. Errors in business logic can be devastating to an entire application.
Initialization and Cleanup	Weaknesses in this category occur in behaviors that are used for initialization and breakdown.
Arguments and Parameters	Weaknesses in this category are related to improper use of arguments or parameters within function calls.
Expression Issues	Weaknesses in this category are related to incorrectly written expressions within code.
Coding Practices	Weaknesses in this category are related to coding practices that are deemed unsafe and increase the chances that an exploitable vulnerability will be present in the application. They may not directly introduce a vulnerability, but indicate the product has not been carefully developed or maintained.

2 Findings

2.1 Summary

Here is a summary of our findings after analyzing the implementation of the `Forced Liquidation` feature in `Venus`. During the first phase of our audit, we study the smart contract source code and run our in-house static code analyzer through the codebase. The purpose here is to statically identify known coding bugs, and then manually verify (reject or confirm) issues reported by our tool. We further manually review business logic, examine system operations, and place DeFi-related aspects under scrutiny to uncover possible pitfalls and/or bugs.

Severity	# of Findings	
Critical	0	
High	0	
Medium	0	
Low	0	
Informational	2	
Total	2	

We have previously audited the main Venus protocol. In this report, we exclusively focus on the specific pull request `PR-332`, we determine three issues that need to be brought up and paid more attention to, which are categorized in the above table. More information can be found in the next subsection, and the detailed discussion of the issues are in Section 3.

2.2 Key Findings

Overall, these smart contracts are well-designed and engineered, though the implementation can be improved by resolving the identified issues (shown in Table 2.1), including 2 informational recommendations.

Table 2.1: Key Audit Findings

ID	Severity	Title	Category	Status
PVE-001	Informational	Minor Interface Inconsistency in UpdatedComptrollerInterface	Coding Practices	Resolved
PVE-002	Informational	Potential Cascading Liquidation From BUSD Forced Liquidation	Business Logic	Resolved

Beside the identified issues, we emphasize that for any user-facing applications and services, it is always important to develop necessary risk-control mechanisms and make contingency plans, which may need to be exercised before the mainnet deployment. The risk-control mechanisms should kick in at the very moment when the contracts are being deployed on mainnet. Please refer to Section 3 for details.

3 | Detailed Results

3.1 Minor Interface Inconsistency in UpdatedComptrollerInterface

- ID: PVE-001
- Severity: Informational
- Likelihood: N/A
- Impact: N/A
- Target: `UpdatedComptrollerInterface`
- Category: Coding Practices [3]
- CWE subcategory: CWE-1126 [1]

Description

The `forced liquidation` feature is proposed to liquidate positions in deprecated markets. In addition to meet the logic requirement, the audited PR also aims to accommodate the code size limit of the `Comptroller` contract, which is now close to the limit. Accordingly, certain public interfaces become internal and one affected interface is `venusSpeeds()`.

To elaborate, we show below the related changes in `ComptrollerStorage` that basically choose not to expose the public getter methods of `venusRate()` and `venusSpeeds()`. Note the last interface is publicly defined in `UpdatedComptrollerInterface`. For consistency, there is a need to revise the changes or update the `UpdatedComptrollerInterface` contract.

```
    VToken[] public allMarkets;

    /// @notice The rate at which the flywheel distributes XVS, per block
-   uint public venusRate;
+   uint internal venusRate;

    /// @notice The portion of venusRate that each market currently receives
-   mapping(address => uint) public venusSpeeds;
+   mapping(address => uint) internal venusSpeeds;

    /// @notice The Venus market supply state for each market
    mapping(address => VenusMarketState) public venusSupplyState;
```

Listing 3.1: Affected States in `ComptrollerStorage`)

```
    function claimVenus(address) external;

    function venusAccrued(address) external view returns (uint);

    function venusSpeeds(address) external view returns (uint);
```

Listing 3.2: Affected `UpdatedComptrollerInterface::venusSpeeds()` Interface

Recommendation Resolve the above-mentioned inconsistency.

Status This issue has been resolved as the `venusSpeeds` interface is already deprecated and not used anymore – as evidenced in the following transaction. 0x4dfb...452

3.2 Potential Cascading Liquidation From BUSD Forced Liquidation

- ID: PVE-002
- Severity: Informational
- Likelihood: N/A
- Impact: N/A
- Target: `Comptroller`
- Category: Business Logic [4]
- CWE subcategory: CWE-841 [2]

Description

As mentioned earlier, the `forced liquidation` feature is proposed to liquidate positions in deprecated markets. If enabled in one market, it will allow anyone to liquidate borrow positions in that market, even on accounts with health rate greater than 1. In particular, the `Venus` protocol has started the deprecation process of the `BUSD` market on August 27th with `VIP-161: https://app.venus.io/#/governance/proposal/161`, which effectively pauses borrows, supplies, blocks entering market, and increases the reserve factor to `100%`.

In the following, we show below the implementation of this feature, which in essence allows the liquidation validation to pass on the enabled market. Note that the normal check on the close factor is also. In other words, it will allow the liquidation of `100%` of the debt in one transaction. While reviewing the change, one specific concern is the possibility of causing cascading liquidations of a user position if the `BUSD` debt is forcedly liquidated. In particular, if a user has the `BUSD` debt, the forced liquidation will take away extra collateral due to current `10%` liquidation incentives, which may further reduce the user health rate below 1 – even if the original rate is well above 1 (if the `BUSD` debt is not forcedly liquidated).

```
    function liquidateBorrowAllowed(
        address vTokenBorrowed,
```

```
        address vTokenCollateral,
        address liquidator,
        address borrower,
        uint repayAmount
    ) external returns (uint) {
        checkProtocolPauseState();

        // if we want to pause liquidating to vTokenCollateral, we should pause seizing
        checkActionPauseState(vTokenBorrowed, Action.LIQUIDATE);

        if (liquidatorContract != address(0) && liquidator != liquidatorContract) {
            return uint(Error.UNAUTHORIZED);
        }

        ensureListed(markets[vTokenCollateral]);

        uint borrowBalance;
        if (address(vTokenBorrowed) != address(vaiController)) {
            ensureListed(markets[vTokenBorrowed]);
            borrowBalance = VToken(vTokenBorrowed).borrowBalanceStored(borrower);
        } else {
            borrowBalance = vaiController.getVAIRepayAmount(borrower);
        }

        if (isForcedLiquidationEnabled[vTokenBorrowed]) {
            if (repayAmount > borrowBalance) {
                return uint(Error.TOO_MUCH_REPAY);
            }
            return uint(Error.NO_ERROR);
        }
        ...
    }
```

Listing 3.3: `Comptroller::liquidateBorrowAllowed()`

Recommendation Thoroughly discuss within the community to notify the potential consequence if this feature is turned on.

Status This issue has been resolved since the team believes the announcement of this `forced liquidation` feature would be an enough intimidation for the borrowers.

4 Conclusion

In this audit, we have analyzed the design and implementation of the `Forced Liquidation` feature in `Venus`. The feature, if enabled in one market, allows borrow positions to be liquidated even when the health rate of the involved user is greater than 1. Moreover, the close factor check would be ignored, allowing the liquidation of `100%` of the debt in one transaction. The current code base is well structured and neatly organized. Those identified issues are promptly confirmed and addressed.

Moreover, we need to emphasize that `Solidity-based` smart contracts as a whole are still in an early, but exciting stage of development. To improve this report, we greatly appreciate any constructive feedbacks or suggestions, on our methodology, audit findings, or potential gaps in scope/coverage.

References

[1] MITRE. CWE-1126: Declaration of Variable with Unnecessarily Wide Scope. https://cwe.mitre.org/data/definitions/1126.html.

[2] MITRE. CWE-841: Improper Enforcement of Behavioral Workflow. https://cwe.mitre.org/data/definitions/841.html.

[3] MITRE. CWE CATEGORY: Bad Coding Practices. https://cwe.mitre.org/data/definitions/1006.html.

[4] MITRE. CWE CATEGORY: Business Logic Errors. https://cwe.mitre.org/data/definitions/840.html.

[5] MITRE. CWE VIEW: Development Concepts. https://cwe.mitre.org/data/definitions/699.html.

[6] OWASP. Risk Rating Methodology. https://www.owasp.org/index.php/OWASP_Risk_Rating_Methodology.

[7] PeckShield. PeckShield Inc. https://www.peckshield.com.