SMART CONTRACT AUDIT REPORT

for

FEG Migrator

Prepared By: Xiaomi Huang

PeckShield

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Contact

For more information about this document and its contents, please contact PeckShield Inc.

Name	Xiaomi Huang
Phone	+86 183 5897 7782
Email	contact@peckshield.com

Contents

1 Introduction

Given the opportunity to review the design document and related source code of the FEG's Migrator contract, 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 can be further improved due to the presence of several issues related to either security or performance. This document outlines our audit results.

1.1 About FEG Migrator

Migrator is an FEG-related tool, which is used to migrate old FEG tokens to new FEG tokens. It accepts old FEG tokens that are directly held by users, or staked in the FEGstake/FEGstakeV2 contracts. Moreover, it has a specific version for the BSC chain and the Ethereum chain. The basic information of the Migrator protocol is as follows:

Table 1.1: Basic Information of The Migrator Protocol

Item	Description
Name	FEG
Type	Ethereum Smart Contract
Platform	Solidity
Audit Method	Whitebox
Latest Audit Report	May 14, 2024

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

- https://github.com/FEGrox/migrators.git (f292b7d)

And this is the commit ID after all fixes for the issues found in the audit have been checked in:

- https://github.com/FEGrox/migrators.git (da5e9d7)

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 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.

To evaluate the risk, we go through a list of check 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

Table 1.3: The Full List of Check Items

Category	Check Item
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

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.

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 Logics	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 FEG's Migrator implementation. 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 logics, 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	2	🟦🟦
Low	1	🟦
Informational	0	
Total	3	

We have so far identified a list of potential issues: some of them involve subtle corner cases that might not be previously thought of, while others refer to unusual interactions among multiple contracts. For each uncovered issue, we have therefore developed test cases for reasoning, reproduction, and/or verification. After further analysis and internal discussion, we determined a few issues of varying severities 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 discussions of each of them 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 medium-severity vulnerabilities and 1 low-severity vulnerability.

Table 2.1: Key FEG Migrator Audit Findings

ID	Severity	Title	Category	Status
PVE-001	Medium	Incorrect roundROX() Logic in Migrator	Business Logic	Resolved
PVE-002	Low	Revisited FEG Claim Logic in claimFEGRelease()	Business Logic	Resolved
PVE-003	Medium	Trust Issue of Admin Keys	Security Features	Mitigated

Besides recommending specific countermeasures to mitigate these issues, we also emphasize that 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 need to kick in at the very moment when the contracts are being deployed in mainnet. Please refer to Section 3 for details.

3 Detailed Results

3.1 Incorrect roundROX() Logic in Migrator

- ID: PVE-001
- Severity: Medium
- Likelihood: Medium
- Impact: Low
- Target: Migrator
- Category: Business Logic [4]
- CWE subcategory: CWE-841 [2]

Description

The Migrator provides users the ability to migrate their old FEG to the new one. It accepts the old FEG tokens that are directly held by users or staked in the FEGstake/FEGstakeV2 contracts. In order to facilitate users migration, it provides two ways for users to migrate their tokens. Firstly, users can migrate their FEG tokens on hand or staked in the FEGstake/FEGstakeV2 contracts separately. Secondly, users can migrate all their FEG tokens in one step.

While examining the next approach to claim or stake the migrated new tokens, we notice the protocol enforces the need of multiple rounds and the current round calculation logic has an issue that needs to be fixed. In the following, we show the implementation of the related roundROX() routine. This routine computes the current round that is available to claim or stake the migrated new tokens. It comes to our attention that the internal if-condition should be revised as if(block.timestamp > timer + (timerROX*round)).

```
    function roundROX() public view returns(uint256 round) {
        round = 1;
        for(uint256 i = 0; i < 26; i++) {
            if(block.timestamp > timer + timerROX) {
                round += 1;
                if(round == 25) {
                    break; //failsafe
                }
            }
        }
```

```
172   }
```

Listing 3.1: `Migrator::roundROX()`

Recommendation Properly revise the `roundROX()` to compute the correct round number.

Status The issue has been fixed by the following commit: `18dcb75`.

3.2 Revisited FEG Claim Logic in claimFEGRelease()

- ID: PVE-003
- Severity: Low
- Likelihood: Low
- Impact: Medium
- Target: `Migrator`
- Category: Business Logic [4]
- CWE subcategory: CWE-841 [2]

Description

As mentioned earlier, the `Migrator` provides users the ability to migrate their old `FEG` to the new one. The migrated new tokens can be claimed in multiple rounds. Each round will allow the user to claim `FEGperDist` amount of `FEG`. In the process of examining the actual claim logic, we notice an issue that incorrectly validate the total amount of tokens to claim.

To elaborate, we show below the related routine, i.e., `claimFEGRelease()`. It basically computes the number of eligible rounds and then total amount to claim. However, it comes to our attention that the maximum amount to claim is computed in `amtOpen`, which should be used to check the request amount as `require(amt <= amtOpen`, not current `require(amt >= amtOpen` (line 216). Note another routine `stakeFEGRelease()` shares the same issue.

```
208 function claimFEGRelease(uint256 amt, uint16 toChain) external noReentrant payable {
209     require(!expired[msg.sender], "expired wallet");
210     require(convertEnabledROX[msg.sender], "not ready");
211     require(block.timestamp > lastClaimed[msg.sender] + 1 hours, "1 day cooldown");
212     require(amt > 0, "cannot claim 0");
213     require(totalFEGFromROXAvailable[msg.sender] >= amt, "over");
214     uint256 tot = roundROX() * FEGperDist[msg.sender];
215     uint256 amtOpen = tot - FEGfromROX[msg.sender];
216     require(amt >= amtOpen, "not enough open");
217     lastClaimed[msg.sender] = block.timestamp;
218     FEGfromROX[msg.sender] += amt;
219     totalFEGFromROXAvailable[msg.sender] -= amt;
220     if(toChain == 0) {
221         TransferHelper.safeTransfer(NEW_FEG, msg.sender, amt);
222     }
223     if(toChain > 0) {
224         address brd = br(dataread).bridgeSD(NEW_FEG);
```

```
        (uint256 cost ,) = br(brd).costBridge(toChain);
        require(msg.value >= cost , "insufficient fee");
        br(brd).bridge{value: cost}(toChain ,amt ,msg.sender);
    }
    emit FEGClaimedForROX(msg.sender , amt , toChain);
}
```

Listing 3.2: Migrator::claimFEGRelease()

Recommendation Revisit the above routines to properly validate the user input amount to claim.

Status The issue has been fixed by the following commits: `18dcb75` and `da5e9d7`.

3.3 Trust Issue of Admin Keys

- ID: PVE-003
- Severity: Medium
- Likelihood: Medium
- Impact: Medium
- Target: `Migrator`
- Category: Security Features [3]
- CWE subcategory: CWE-287 [1]

Description

In the `Migrator` contract, there is a privileged account, i.e., `admin`, that can rescue tokens from the contract. Our analysis shows that the privileged account need to be scrutinized. In the following, we show the function potentially affected by the privilege of the `admin` account.

```
    function setLive(bool _bool) external {
        require(dr(dataread).superAdmin(msg.sender));
        live = _bool;
    }

    function setBurnThreshold(uint256 amt) external {
        require(dr(dataread).superAdmin(msg.sender));
        burnThreshold = amt;
    }

    function setExp(address user , bool _bool) external {
        require(dr(dataread).isAdmin(msg.sender));
        expired[user] = _bool;
    }
    ...
    function saveLostTokens(address toSave) external { //added function to save any lost
         tokens
        require(OLDFEG != toSave ,"Can't extract FEG");
        require(FEG != toSave ,"Can't extract FEG"); // only burn for backing
        require(V_2 != toSave ,"Can't extract V-2");
        require(WETH() != toSave,"Can't extract WETH");
        require(dr(dataread).superAdmin(msg.sender));
        uint256 toSend = IERC20(toSave).balanceOf(address(this));
        TransferHelper.safeTransfer(toSave,dev,toSend);
        emit SaveLostTokens(toSave, toSend);
    }
```

Listing 3.3: Example Privileged Operations in Migrator

We understand the need of the privileged function for contract maintenance, but at the same time the extra power to the `admin` may also be a counter-party risk to the protocol users. It is worrisome if the privileged `admin` account is plain EOA account. Note that a multi-sig account could greatly alleviate this concern, though it is still far from perfect. Specifically, a better approach is to eliminate the administration key concern by transferring the role to a community-governed DAO.

Recommendation Promptly transfer the privileged account to the intended `DAO`-like governance contract. All changed to privileged operations may need to be mediated with necessary timelocks. Eventually, activate the normal on-chain community-based governance life-cycle and ensure the intended trustless nature and high-quality distributed governance.

Status This issue has been mitigated as the team confirms they plan to use multi-sig for the `owner` account.

4 | Conclusion

In this audit, we have analyzed the design and implementation of the `FEG Migrator` contract, which is design to migrate old `FEG` to a new one. It accepts the old `FEG` tokens that are directly held by users, or staked in the `FEGstake/FEGstakeV2` contracts. Moreover, it has a specific version for the `BSC` chain and the `Ethereum` chain. During the audit, we notice that the current code base is well organized and those identified issues are promptly mitigated and fixed.

Meanwhile, we need to emphasize that 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-287: Improper Authentication. https://cwe.mitre.org/data/definitions/287.html.

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

[3] MITRE. CWE CATEGORY: 7PK - Security Features. https://cwe.mitre.org/data/definitions/254.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.