SMART CONTRACT AUDIT REPORT

for

Okse StableCoinConverter

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1 | Introduction

Given the opportunity to review the design document and related smart contract source code of the `Okse StableCoinConverter` protocol, 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 Okse StableCoinConverter

`Okse` is a decentralized non-custodial system built to revolutionize the financial market. Its core `Okse Card` protocol allows the users to access and spend their cryptocurrency without counter-party risk in over 60 million shops worldwide. The audited `StableCoinConverter` contract converts all funds out of the debit card contract into `USDC` on as `ERC20` (using the bridge `celer.network`) and send the funds directly to the payment provider. The basic information of the audited protocol is as follows:

Table 1.1: Basic Information of Okse StableCoinConverter

Item	Description
Target	Okse StableCoinConverter
Type	EVM Smart Contract
Language	Solidity
Audit Method	Whitebox
Latest Audit Report	November 13, 2022

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

- https://github.com/Okseio/okse-secondary-contracts.git (924c4e9)

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

- https://github.com/Okseio/okse-secondary-contracts.git (27bd657)

1.2 About PeckShield

PeckShield Inc. [9] 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 [8]:

- 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

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

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) [7], 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 `Okse StableCoinConverter` 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 logic, examine system operations, and place DeFi-related aspects under scrutiny to uncover possible pitfalls and/or bugs.

Severity	# of Findings	
Critical	1	■
High	0	
Medium	1	■
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 1 critical-severity vulnerability, 1 medium-severity vulnerability, and 1 low-severity vulnerability.

Table 2.1: Key Okse StableCoinConverter Audit Findings

ID	Severity	Title	Category	Status
PVE-001	Critical	Revisited Fund Approval Authorization in StableCoinConverter	Coding Practices	Resolved
PVE-002	Low	Accommodation of Non-ERC20-Compliant Tokens	Coding Practices	Resolved
PVE-003	Medium	Trust Issue of Admin Keys	Security Features	Mitigated

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 Revisited Fund Approval Authorization in StableCoinConverter

- ID: PVE-001
- Severity: Critical
- Likelihood: High
- Impact: High
- Target: `StableCoinConverter`
- Category: Coding Practices [5]
- CWE subcategory: CWE-1041 [1]

Description

The given `StableCoinConverter` contract is designed to convert all funds which are coming out of the debit card contract into `USDC` on as `ERC20` (using the bridge `celer.network`) and send the funds directly to the payment provider. While reviewing its logic, we notice the current approval logic may be exploited to drain funds from the contract.

To elaborate, we show below the affected function `StableCoinConverter::approve()`, which is designed to approve a trusted entity to move funds out of the contract. However, it comes to our attention that the sensitive function is not guarded and anyone may invoke it to have the ability to move funds out of the contract!

```
function approve(address _token, address target) external {
    ERC20Interface(_token).approve(target, UINT_MAX);
}
```

Listing 3.1: `StableCoinConverter::approve()`

Recommendation Validate the caller or the given `target` in the above `approve()` function.

Status This issue has been fixed by properly validating the given `target` as follows:

```
function approve(address _token, address target) external onlyOwner {
    require(
        target == bridge  target == exchanger,
```

```
            "invalid approve target"
        );
        TransferHelper.safeApprove(_token, target, UINT_MAX);
    }
```

Listing 3.2: StableCoinConverter::approve()

3.2 Accommodation of Non-ERC20-Compliant Tokens

- ID: PVE-002
- Severity: Low
- Likelihood: Low
- Impact: Low
- Target: Multiple Contracts
- Category: Business Logic [6]
- CWE subcategory: CWE-841 [3]

Description

Though there is a standardized ERC-20 specification, many token contracts may not strictly follow the specification or have additional functionalities beyond the specification. In this section, we examine the approve() routine and possible idiosyncrasies from current widely-used token contracts.

In particular, we use the popular stablecoin, i.e., USDT, as our example. We show the related code snippet below. Specifically, the approve() routine does not have a return value defined and implemented. However, the IERC20 interface has defined the approve() interface with a bool return value. As a result, the call to approve() may expect a return value. With the lack of return value of USDT's approve(), the call will be unfortunately reverted.

```
    function approve(address _spender, uint _value) public onlyPayloadSize(2 * 32) {

        // To change the approve amount you first have to reduce the addresses`
        //  allowance to zero by calling `approve(_spender, 0)` if it is not
        //  already 0 to mitigate the race condition described here:
        //  https://github.com/ethereum/EIPs/issues/20#issuecomment-263524729
        require(!((_value != 0) && (allowed[msg.sender][_spender] != 0)));

        allowed[msg.sender][_spender] = _value;
        Approval(msg.sender, _spender, _value);
    }
```

Listing 3.3: USDT Token Contract

Because of that, a normal call to approve() is suggested to use the safe version, i.e., safeApprove() . In essence, it is a wrapper around ERC20 operations that may either throw on failure or return false without reverts. Moreover, the safe version also supports tokens that return no value (and instead revert or throw on failure). Note that non-reverting calls are assumed to be successful. Similarly, there is a safe version of `transfer()`/`transferFrom()` as well, i.e., `safeTransfer()`/`safeTransferFrom()`.

In the following, we show the `approve()` routine in the `StableCoinConverter` contract. If the `USDT` token is supported as `token`, the unsafe version of `ERC20Interface(_token).approve(target, UINT_MAX)` (line 104) may revert as there is no return value in the `USDT` token contract's `approve()` implementation (but the `IERC20` interface expects a return value).

```
103     function approve(address _token, address target) external {
104         ERC20Interface(_token).approve(target, UINT_MAX);
105     }
```

Listing 3.4: `StableCoinConverter::approve()`

Recommendation Accommodate the above-mentioned idiosyncrasy about ERC20-related `transfer()`/`transferFrom()`/`approve()`. Regarding the improved `approve()` logic, there is a need to `approve()` twice: the first one reduces the allowance to 0; and the second one sets the new allowance.

Status This issue has been fixed in the commit: 27bd657.

3.3 Trust Issue Of Admin Keys

- ID: PVE-003
- Severity: Medium
- Likelihood: Medium
- Impact: Medium
- Target: `StableCoinConverter`
- Category: Security Features [4]
- CWE subcategory: CWE-287 [2]

Description

In the `Okse StableCoinConverter` contract, there is a privileged `owner` account that plays a critical role in governing and regulating the protocol-wide operations (e.g., configure various system parameters and perform sensitive operations for fund withdrawals). In the following, we show the representative functions potentially affected by the privilege of the `owner` account.

```
    function runManual(uint256 _slippage) external onlyOwner {
        // check balance
        uint256 tokenBalance = ERC20Interface(token).balanceOf(address(this));
        // execute
        if (exchanger != address(0)) {
            swap(tokenBalance);
        }
        tokenBalance = ERC20Interface(usdc).balanceOf(address(this));
        send(tokenBalance, _slippage);
        uint256 lastExecuteTime = block.timestamp;
        emit Executed(tokenBalance, lastExecuteTime, bridge);
```

```
    }

    function setMinimumAmount(uint256 _minAmount) public onlyOwner {
        minAmount = _minAmount;
        emit MinAmountChanged(minAmount);
    }

    function setSlippage(uint256 _slippage) external onlyOwner {
        slippage = _slippage;
    }

    function stop() external onlyOwner {
        stopped = true;
        stoppedTime = block.timestamp;
        emit Stopped(stoppedTime);
    }

    function start() external onlyOwner {
        stopped = false;
        emit Started(block.timestamp);
    }
```

Listing 3.5: `StableCoinConverter`

We emphasize that the privilege assignment is indeed necessary and consistent with the protocol design. However, it is worrisome if the privileged account is a plain EOA account. A multi-sig account could greatly alleviate this concern, though it is still far from perfect. Note that a compromised privileged account would allow the attacker to modify a number of sensitive system parameters, which directly undermines the assumption of the protocol design.

Recommendation Suggest a multi-sig account plays the privileged `owner` account to mitigate this issue. Additionally, all changes to privileged operations may need to be mediated with necessary timelocks.

Status This issue has been mitigated via introducing `multi-sig` mechanism in the protocol.

4 | Conclusion

In this audit, we have analyzed the `Okse StableCoinConverter` design and implementation. `Okse` is a decentralized non-custodial system built to revolutionize the financial market. The audited `StableCoinConverter` contract converts all funds which are coming out of the debit card contract into `USDC` on as `ERC20` (using the bridge `celer.network`) and send the funds directly to the payment provider. The current code base is well structured and neatly organized. Those identified issues are promptly confirmed and addressed.

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-1041: Use of Redundant Code. https://cwe.mitre.org/data/definitions/1041.html.

[2] MITRE. CWE-287: Improper Authentication. https://cwe.mitre.org/data/definitions/287.html.

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

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

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

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

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

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

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