OMNISCIA

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SMART CONTRACT AUDIT REPORT

Plutus DAO
Hedge Vault

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Online report: plutus-dao-hedge-vault

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Hedge Vault Security Audit

Audit Report Revisions

Commit Hash	Date	Audit Report Hash
eb8a76b31d	December 16th 2024	8ad9200177
af82504254	January 8th 2025	e4a293ac51

Audit Overview

We were tasked with performing an audit of the Plutus DAO codebase and in particular their Hedge Vault **EIP-4626** contract.

The implementation represents a basic **EIP-4626** vault with pausability features, upgradeability, a total deposit limitation system, as well as a mechanism to extract and return funds from and to the vault for trading / strategy activities.

As the contract implements a centralized trading / strategy resource allocation mechanism, we strongly advise utmost care to be taken in the deployment of the system and the maintenance of the relevant access keys to ensure funds are appropriately allocated and utilized.

Over the course of the audit, we identified several deviations from the **EIP-4626** standard all stemming from the various limitations the standard defines that have not been properly overridden in the Hedge Vault implementation.

We advise the Plutus DAO team to closely evaluate all minor-and-above findings identified in the report and promptly remediate them as well as consider all optimizational exhibits identified in the report.

Post-Audit Conclusion

The Plutus DAO team iterated through all findings within the report and provided us with a revised commit hash to evaluate all exhibits on.

We evaluated all alleviations performed by Plutus DAO and have identified that certain exhibits have not been adequately dealt with. We advise the Plutus DAO team to revisit the following exhibits: `HVT-03M`, `HVT-04M`

Post-Audit Conclusion (af82504254)

The Plutus DAO team provided us with a follow-up commit hash to evaluate the remediative actions carried out for the two aforementioned open exhibits.

We validated that both exhibits have been alleviated in an exemplary manner, and thus consider all outputs of the audit report properly consumed by the Plutus DAO team with no outstanding remediative actions.

Audit Synopsis

Severity	Identified	Alleviated	Partially Alleviated	Acknowledged
Unknown	0	0	0	0
Informational	3	3	0	0
Minor	1	1	0	0
Medium	2	2	0	0
Major	0	0	0	0

During the audit, we filtered and validated a total of **0 findings utilizing static analysis** tools as well as identified a total of **6 findings during the manual review** of the codebase. We strongly recommend that any minor severity or higher findings are dealt with promptly prior to the project's launch as they can introduce potential misbehaviours of the system as well as exploits.

- 🎯 **Scope**
- 💻 **Compilation**
- 🔍 **Static Analysis**
- 👁️ **Manual Review**
- 🖌️ **Code Style**

Scope

The audit engagement encompassed a specific list of contracts that were present in the commit hash of the repository that was in scope. The tables below detail certain meta-data about the target of the security assessment and a navigation chart is present at the end that links to the relevant findings per file.

Target

- Repository: **https://github.com/PlutusDao/plvHEDGE-omniscia**
- Commit: f867f50936fdb9d3d8b1ac6c9ee7cf0beedc609a
- Language: Solidity
- Network: Arbitrum
- Revisions: **f867f50936**, **eb8a76b31d**, **af82504254**

Contracts Assessed

File	Total Finding(s)
src/HedgeVault.sol (HVT)	6

Compilation

The project utilizes `foundry` as its development pipeline tool, containing an array of tests and scripts coded in Solidity.

To compile the project, the `build` command needs to be issued via the `forge` CLI tool:

```bash
forge build
```

The `forge` tool automatically selects Solidity version `0.8.28` based on the version specified within the `foundry.toml` file.

The project contains discrepancies with regards to the Solidity version used, however, they are solely located in external dependencies and can thus be safely ignored.

The `pragma` statements have been locked to `0.8.28` (`=0.8.28`), the same version utilized for our static analysis as well as optimizational review of the codebase.

During compilation with the `foundry` pipeline, no errors were identified that relate to the syntax or bytecode size of the contracts.

Static Analysis

The execution of our static analysis toolkit identified **6 potential issues** within the codebase of which **6 were ruled out to be false positives** or negligible findings.

Manual Review

A **thorough line-by-line review** was conducted on the codebase to identify potential malfunctions and vulnerabilities in Plutus DAO's Hedge Vault.

As the project at hand implements an EIP-4626 vault, intricate care was put into ensuring that the **flow of funds within the system conforms to the specifications and restrictions** laid forth within the protocol's specification.

We validated that **all state transitions of the system occur within sane criteria** and that all rudimentary formulas within the system execute as expected. We **pinpointed multiple EIP deviancies** within the system which could have had **minor-to-moderate ramifications** to its overall operation; we advise all non-informational exhibits within the audit report to be closely examined.

Additionally, the system was investigated for any other commonly present attack vectors such as re-entrancy attacks, mathematical truncations, logical flaws and **ERC / EIP** standard inconsistencies. The documentation of the project was satisfactory to the extent it need be, however, the purpose of the `controller` notion in the codebase is unknown and should be clarified by the Plutus DAO team.

A total of **6 findings** were identified over the course of the manual review of which **4 findings** concerned the behaviour and security of the system. The non-security related findings, such as optimizations, are included in the separate **Code Style** chapter.

The finding table below enumerates all these security / behavioural findings:

ID	Severity	Addressed	Title
HVT-01M	Informational	Yes	Unused Code
HVT-02M	Minor	Yes	Inexistent Reflection of Pause State in All EIP-4626 Limits
HVT-03M	Medium	Yes	Improper Enforcement of Total Deposit Limits
HVT-04M	Medium	Yes	Inexistent Reflection of Strategy Funds in Withdrawal / Redemption

Code Style

During the manual portion of the audit, we identified **2 optimizations** that can be applied to the codebase that will decrease the operational cost associated with the execution of a particular function and generally ensure that the project complies with the latest best practices and standards in Solidity.

Additionally, this section of the audit contains any opinionated adjustments we believe the code should make to make it more legible as well as truer to its purpose.

These optimizations are enumerated below:

ID	Severity	Addressed	Title
HVT-01C	Informational	Yes	Ineffectual Usage of Safe Arithmetics
HVT-02C	Informational	Yes	Redundant Parenthesis Statements

HedgeVault Manual Review Findings

HVT-01M: Unused Code

Type	Severity	Location
Logical Fault	Informational	HedgeVault.sol:L91-L94

Description:

The `HedgeVault::onlyController` modifier remains unused within the codebase, rendering the `controller` notion a contract variable that can be maintained yet is not utilized.

Example:

src/HedgeVault.sol

SOL

```sol
91  modifier onlyController() {
92      if (msg.sender != controller) revert OnlyController();
93      _;
94  }
```

Recommendation:

We advise the `controller` variable's purpose to be clearly defined and the relevant modifier to either be omitted or properly used in the code.

Alleviation (eb8a76b31db4a988b7437048e5866795f978ff91):

The referenced unused code has been safely omitted, optimizing the code's bytecode size.

HVT-02M: Inexistent Reflection of Pause State in All EIP-4626 Limits

Type	Severity	Location
Standard Conformity	Minor	**HedgeVault.sol**: • I-1: **L267** • I-2: **L276**

Description:

Per the **EIP-4626** standard, all inflow / outflow limitations should reflect a value of `0` if such functionality is temporarily unavailable (i.e. in case it is paused).

The `HedgeVault` does not accommodate for such scenarios thereby not complying with the standard.

Impact:

The inflow / outflow **EIP-4626** limits of the `HedgeVault` do not reflect the contract's paused states causing it to deviate from the **EIP-4626** standard.

Example:

src/HedgeVault.sol

SOL

```sol
261 /**
262  * @notice Updates the withdrawal pause status
263  * @param paused New pause status
264  */
265
266 function setWithdrawalsPaused(bool paused) external override
onlyRole(DEFAULT_ADMIN_ROLE) {
267     withdrawalsPaused = paused;
268     emit WithdrawalsStatusUpdated(paused);
269 }
270 /**
```

Example (Cont.):

```sol
 * @notice Updates the deposit pause status
 * @param paused New pause status
 */

function setDepositsPaused(bool paused) external override onlyRole(DEFAULT_ADMIN_ROLE) {
    depositsPaused = paused;
    emit DepositsStatusUpdated(paused);
}
```

Recommendation:

We advise the relevant functions to be properly overridden and the pause state of each functionality in the contract to be evaluated, yielding appropriate limits for each corresponding **EIP-4626** interaction.

Alleviation (eb8a76b31db4a988b7437048e5866795f978ff91):

The relevant **EIP-4626** functions have been properly overridden to yield `0` limits if the deposit or withdrawal mechanisms are paused in each respective function, addressing this exhibit in full.

HVT-03M: Improper Enforcement of Total Deposit Limits

Type	Severity	Location
Standard Conformity	Medium	**HedgeVault.sol**: • I-1: **L129-L131** • I-2: **L147-L149**

Description:

Per the **EIP-4626** standard, the deposit and mint functions should allow values up to the `IERC4626::maxDeposit` and `IERC4626::maxMint` function results.

The `HedgeVault` does not override these functions thereby breaching the standard and enforcing custom limitations via the deposit and mint functions directly.

Impact:

Integrators of the `HedgeVault` will fail to interact with it in certain circumstances as the deposit limit of the vault is not properly reflected in **EIP-4626** functions using **MUST** terminology.

Example:

src/HedgeVault.sol

SOL

```sol
123 /**
124  * @notice Deposits tokens into the vault
125  * @dev Updates internal accounting of total assets
126  */
127 function deposit(uint256 assets, address receiver) public
override(ERC4626Upgradeable, IHedgeVault) nonReentrant returns (uint256) {
128     if (depositsPaused) revert DepositsArePaused();
129     if (_totalDeposits + assets > maxTotalDeposit) {
130         revert MaxTotalDepositExceeded();
131     }
132
```

Example (Cont.):

```sol
    uint256 shares = super.deposit(assets, receiver);
    _totalAssets += assets;
    _totalDeposits += assets;
    return shares;
}
/**
 * @notice Mints vault shares
 * @dev Updates internal accounting of total assets
 */

function mint(uint256 shares, address receiver) public
override(ERC4626Upgradeable, IHedgeVault) nonReentrant returns (uint256) {
    if (depositsPaused) revert DepositsArePaused();

    uint256 assets = previewMint(shares);
    if (_totalDeposits + assets > maxTotalDeposit) {
        revert MaxTotalDepositExceeded();
    }

    uint256 actualAssets = super.mint(shares, receiver);
    _totalAssets += actualAssets;
    _totalDeposits += actualAssets;

    return actualAssets;
}
```

Recommendation:

We advise those functions to be properly overridden, permitting the deposit limits imposed on the `HedgeVault::deposit` and `HedgeVault::mint` functions to be omitted and ensuring the contract is properly compatible with the **EIP-4626** standard.

Alleviation (eb8a76b31d):

While the relevant **EIP-4626** max limits have been properly configured, the `HedgeVault::deposit` and `HedgeVault::mint` functions continue to locally impose those limits inefficiently given that they are already imposed by the `ERC4626Upgradeable` implementation.

We advise the `maxTotalDeposit` limitation enforcement to be removed locally, further optimizing the code's gas costs.

Alleviation (af82504254):

The `maxTotalDeposit` local limitations have been removed as advised, optimizing the code further and thus rendering this exhibit fully alleviated.

HVT-04M: Inexistent Reflection of Strategy Funds in Withdrawal / Redemption Limits

Type	Severity	Location
Standard Conformity	Medium	HedgeVault.sol:L213

Description:

Per the **EIP-4626** standard, the withdraw and redeem functions should allow values up to the `IERC4626::maxWithdraw` and `IERC4626::maxRedeem` function results.

The `HedgeVault` does not override these functions thereby breaching the standard as a withdrawal / redemption will fail for funds that are currently in trading.

Impact:

Integrators of the `HedgeVault` might attempt to withdraw funds that are currently being traded and thus might consider the vault to be misbehaving as it is not compliant with the **EIP-4626** standard.

Example:

src/HedgeVault.sol

SOL

```sol
203 /**
204  * @notice Allows controller to take funds for a trader
205  * @param trader Address of the trader
206  * @param amount Amount to take
207  */
208 function fundStrategy(address trader, uint256 amount) external override
onlyRole(SAY_TRADER_ROLE) {
209     // Check if enough available funds
210     uint256 availableFunds = _totalAssets;
211     if (amount > availableFunds) revert InsufficientAvailableFunds();
212
```

Example (Cont.):

```sol
    fundsInTrading += amount;
    IERC20(asset()).safeTransfer(trader, amount);

    emit StrategyFunded(trader, amount);
}
```

Recommendation:

We advise the relevant functions to be overridden and the `fundsInTrading` to be accommodated for, ensuring that up to `_totalAssets - fundsInTrading` can be withdrawn / redeemed at any given point in time.

Alleviation (eb8a76b31d):

The Plutus DAO team evaluated this exhibit and stated that the system's intended usage is to have its withdrawals set to a paused state whenever funds are extracted from the system through the **`HedgeVault::fundStrategy`** function.

We believe that such a trait should be enforced by the code itself and we advise this to be done so by ensuring that the system's withdrawals are paused whenever `fundsInTrading` is non-zero in addition to the manual configuration flag.

Alleviation (af82504254):

The code has applied our recommendation in a highly standardized way by updating the `IERC4626::maxWithdraw` and `IERC4626::maxRedeem` functions to yield `0` if the `fundsInTrading` are non-zero, ensuring that withdrawals / redemptions are paused and properly signaled as such to external observers if there are any funds in trading.

HedgeVault Code Style Findings

HVT-01C: Ineffectual Usage of Safe Arithmetics

Type	Severity	Location
Language Specific	Informational	HedgeVault.sol:L173, L193

Description:

The linked mathematical operations are guaranteed to be performed safely by surrounding conditionals evaluated in either `require` checks or `if-else` constructs.

Example:

src/HedgeVault.sol

SOL

```
172 _totalDeposits = (_totalDeposits > assets)
173 ? _totalDeposits - assets
174 : 0;
```

Recommendation:

Given that safe arithmetics are toggled on by default in `pragma` versions of `0.8.X`, we advise the linked statements to be wrapped in `unchecked` code blocks thereby optimizing their execution cost.

Alleviation (eb8a76b31db4a988b7437048e5866795f978ff91):

Both arithmetic operations have been safely wrapped in `unchecked` code blocks, optimizing their gas costs.

HVT-02C: Redundant Parenthesis Statements

Type	Severity	Location
Code Style	Informational	HedgeVault.sol:L172, L192

Description:

The referenced statements are redundantly wrapped in parenthesis' (`()`).

Example:

src/HedgeVault.sol

SOL

```sol
172 _totalDeposits = (_totalDeposits > assets)
```

Recommendation:

We advise them to be safely omitted, increasing the legibility of the codebase.

Alleviation (eb8a76b31db4a988b7437048e5866795f978ff91):

The redundant parenthesis in the referenced statements have been safely omitted.

Finding Types

A description of each finding type included in the report can be found below and is linked by each respective finding. A full list of finding types Omniscia has defined will be viewable at the central audit methodology we will publish soon.

Input Sanitization

As there are no inherent guarantees to the inputs a function accepts, a set of guards should always be in place to sanitize the values passed in to a particular function.

Indeterminate Code

These types of issues arise when a linked code segment may not behave as expected, either due to mistyped code, convoluted if blocks, overlapping functions / variable names and other ambiguous statements.

Language Specific

Language specific issues arise from certain peculiarities that the Circom language boasts that discerns it from other conventional programming languages.

Curve Specific

Circom defaults to using the BN128 scalar field (a 254-bit prime field), but it also supports BSL12-381 (which has a 255-bit scalar field) and Goldilocks (with a 64-bit scalar field). However, since there are no constants denoting either the prime or the prime size in bits available in the Circom language, some Circomlib templates like `Sign` (which returns the sign of the input signal), and `AliasCheck` (used by the strict versions of `Num2Bits` and `Bits2Num`), hardcode either the BN128 prime size or some other constant related to BN128. Using these circuits with a custom prime may thus lead to unexpected results and should be avoided.

Code Style

In these types of findings, we identify whether a project conforms to a particular naming convention and whether that convention is consistent within the codebase and legible. In case of inconsistencies, we point them out under this category. Additionally, variable shadowing falls under this category as well which is identified when a local-level variable contains the same name as a toplevel variable in the circuit.

Mathematical Operations

This category is used when a mathematical issue is identified. This implies an issue with the implementation of a calculation compared to the specifications.

Logical Fault

This category is a bit broad and is meant to cover implementations that contain flaws in the way they are implemented, either due to unimplemented functionality, unaccounted-for edge cases or similar extraordinary scenarios.

Privacy Concern

This category is used when information that is meant to be kept private is made public in some way.

Proof Concern

Under-constrained signals are one of the most common issues in zero-knowledge circuits. Issues with proof generation fall under this category.

Severity Definition

In the ever-evolving world of blockchain technology, vulnerabilities continue to take on new forms and arise as more innovative projects manifest, new blockchain-level features are introduced, and novel layer-2 solutions are launched. When performing security reviews, we are tasked with classifying the various types of vulnerabilities we identify into subcategories to better aid our readers in understanding their impact.

Within this page, we will clarify what each severity level stands for and our approach in categorizing the findings we pinpoint in our audits. To note, all severity assessments are performed **as if the contract's logic cannot be upgraded** regardless of the underlying implementation.

Severity Levels

There are five distinct severity levels within our reports; `unknown`, `informational`, `minor`, `medium`, and `major`. A TL;DR overview table can be found below as well as a dedicated chapter to each severity level:

	Impact (None)	Impact (Low)	Impact (Moderate)	Impact (High)
Likelihood (None)	Informational	Informational	Informational	Informational
Likelihood (Low)	Informational	Minor	Minor	Medium
Likelihood (Moderate)	Informational	Minor	Medium	Major
Likelihood (High)	Informational	Medium	Major	Major

Unknown Severity

The `unknown` severity level is reserved for misbehaviors we observe in the codebase that cannot be quantified using the above metrics. Examples of such vulnerabilities include potentially desirable system behavior that is undocumented, reliance on external dependencies that are out-of-scope but could result in some form of vulnerability arising, use of external out-of-scope contracts that appears incorrect but cannot be pinpointed, and other such vulnerabilities.

In general, `unknown` severity level vulnerabilities require follow-up information by the project being audited and are either adjusted in severity (if valid), or marked as nullified (if invalid).

Additionally, the `unknown` severity level is sometimes assigned to centralization issues that cannot be assessed in likelihood due to their exploitation being tied to the honesty of the project's team.

Informational Severity

The `informational` severity level is dedicated to findings that do not affect the code functionally and tend to be stylistic or optimizational in nature. Certain edge cases are also set under `informational` vulnerabilities, such as overflow operations that will not manifest in the lifetime of the contract but should be guarded against as a best practice, to give an example.

Minor Severity

The `minor` severity level is meant for vulnerabilities that require functional changes in the code but tend to either have little impact or be unlikely to be recreated in a production environment. These findings can be acknowledged except for findings with a moderate impact but low likelihood which must be alleviated.

Medium Severity

The `medium` severity level is assigned to vulnerabilities that must be alleviated and have an observable impact on the overall project. These findings can only be acknowdged if the project deems them desirable behavior and we disagree with their point-of-view, instead urging them to reconsider their stance while marking the exhibit as acknowledged given that the project has ultimate say as to what vulnerabilities they end up patching in their system.

Major Severity

The `major` severity level is the maximum that can be specified for a finding and indicates a significant flaw in the code that must be alleviated.

Likelihood & Impact Assessment

As the preface chapter specifies, the blockchain space is constantly reinventing itself meaning that new vulnerabilities take place and our understanding of what security means differs year-to-year.

In order to reliably assess the likelihood and impact of a particular vulnerability, we instead apply an abstract measurement of a vulnerability's impact, duration the impact is applied for, and probability that the vulnerability would be exploited in a production environment.

Our proposed definitions are inspired by multiple sources in the security community and are as follows:

- Impact (High): A core invariant of the protocol can be broken for an extended duration.
- Impact (Moderate): A non-core invariant of the protocol can be broken for an extended duration or at scale, or an otherwise major-severity issue is reduced due to hypotheticals or external factors affecting likelihood.
- Impact (Low): A non-core invariant of the protocol can be broken with reduced likelihood or impact.
- Impact (None): A code or documentation flaw whose impact does not achieve low severity, or an issue without theoretical impact; a valuable best-practice
- Likelihood (High): A flaw in the code that can be exploited trivially and is ever-present.
- Likelihood (Moderate): A flaw in the code that requires some external factors to be exploited that are likely to manifest in practice.
- Likelihood (Low): A flaw in the code that requires multiple external factors to be exploited that may manifest in practice but would be unlikely to do so.
- Likelihood (None): A flaw in the code that requires external factors proven to be impossible in a production environment, either due to mathematical constraints, operational constraints, or system-related factors (i.e. EIP-20 tokens not being re-entrant).

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