PRIVATE

Code Assessment

of the Gearbox V3 Core Smart Contracts

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Produced for

Gearbox

by

CHAINSECURITY

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1 Executive Summary

Dear Gearbox Team,

Thank you for trusting us to help Gearbox Protocol with this security audit. Our executive summary provides an overview of subjects covered in our audit of the latest reviewed contracts of Gearbox V3 Core according to Scope to support you in forming an opinion on their security risks.

Gearbox Protocol implements the third version of the core Gearbox protocol, a protocol that allows users to open leveraged positions on various protocols.

The most critical subjects covered in our audit are the correctness of the accounting of the debt, the interest and the fees, the voting, the implementation of the quotas and the opportunities to execute arbitrary code. The most important issue Too Many Bots Can Block Liquidation uncovered could temporarily prevent the liquidation of a credit account. The issue has been fixed. During the fixes review a critical issue Anyone Can Redistribute The Votes was uncoverd which completely breaks the voting mechanism used by the sytem. Security regarding the rest of the aforementioned subjects is high. It is important to note that the project is significantly exposed to errors or misunderstandings in the functionality of integrated third-party systems. Reviewing these external systems for correctness was out of the scope for this audit.

The general subjects covered are access control, documentation and specification, gas efficiency, and the complexity of the implementation. Security regarding all the aforementioned subjects is high, however, we need to emphasize that the code complexity is high.

In summary, we find that the codebase could provide a high level of security should all the issues be fixed and no more issues are uncovered during the review of their fixes.

It is important to note that security audits are time-boxed and cannot uncover all vulnerabilities. They complement but don't replace other vital measures to secure a project.

The following sections will give an overview of the system, our methodology, the issues uncovered and how they have been addressed. We are happy to receive questions and feedback to improve our service.

Sincerely yours,

ChainSecurity

1.1 Overview of the Findings

Below we provide a brief numerical overview of the findings and how they have been addressed.

Critical-Severity Findings	1
• No Response	1
High-Severity Findings	0
Medium-Severity Findings	1
• Code Corrected	1
Low-Severity Findings	6
• Code Corrected	5
• Risk Accepted	1

2 Assessment Overview

In this section, we briefly describe the overall structure and scope of the engagement, including the code commit which is referenced throughout this report.

2.1 Scope

The assessment was performed on the source code files inside the Gearbox V3 Core repository based on the documentation files. The table below indicates the code versions relevant to this report and when they were received.

V	Date	Commit Hash	Note
1	06 June 2023	527b365c97abcface94da4872c4c05a3f1e70d6b	Initial Version
2	10 July 2023	44d2c116885f0f90725d2cc66201766141a1b23b	Fixes Review

For the solidity smart contracts, the compiler version 0.8.17 was chosen.

The following contracts are included in scope:

```
core:
    AbstractAdapter.sol
    AccountFactoryV3.sol
    AddressProviderV3.sol
    BotListV3.sol
    WithdrawalManagerV3.sol

credit:
    CreditAccountV3.sol
    CreditConfiguratorV3.sol
    CreditFacadeV3.sol
    CreditManagerV3.sol
    CreditManagerV3_USDT.sol

governance:
    ControllerTimelockV3.sol
    GaugeV3.sol
    GearStakingV3.sol
    PolicyManagerV3.sol

libraries:
    BalancesLogic.sol
    BitMask.sol
    CollateralLogic.sol
    CreditAccountHelper.sol
    CreditLogic.sol
    QuotasLogic.sol
    USDTFees.sol
    UnsafeERC20.sol
    WithdrawalsLogic.sol
```

```
pool:
    LinearInterestRateModelV3.sol
    PoolQuotaKeeperV3.sol
    PoolV3.sol
    PoolV3_USDT.sol

traits:
    ACLNonReentrantTrait.sol
    ACLTrait.sol
    ContractsRegisterTrait.sol
    ReentrancyGuardTrait.sol
    SanityCheckTrait.sol
    USDT_Transfer.sol
```

2.1.1 Excluded from scope

All the contracts not explicitly in scope are considered out-of-scope. Moreover, all the contracts used in the implementation such as the OpenZeppelin library are considered to work as expected. The parameters of the system are assumed to be properly set. The system integrates with external protocols through adapters which are assumed to operate properly, and their implementation is not part of the current review. The compatibility with previously deployed contracts, typically core systems of Gearbox V1 and V2, is out of the scope of this review.

3 System Overview

This system overview describes the initially received version (Version 1) of the contracts as defined in the Assessment Overview.

Furthermore, in the findings section, we have added a version icon to each of the findings to increase the readability of the report.

Gearbox Protocol offers a general-purpose leverage protocol for `ERC20` tokens. The system is modular and consists of different parts.

3.1 Credit System

The credit system consists of the following four core contracts: `CreditAccount`, `CreditManager`, `CreditFacade`, `CreditConfigurator`.

3.1.1 `CreditAccount`

A Credit Account (CA) represents a leverage position and holds all the position's balances acting essentially as a wallet. The owner's access to this wallet is restricted as it contains additional funds borrowed from the pool. Interaction with external protocols using the funds of the credit account can be executed through the respective adapters.

3.1.2 CreditManager

Each Credit Manager (CM) is tied to an underlying token and is connected to a liquidity pool with the same underlying token. The CM holds all the computational logic regarding the increase/decrease of the debt, the payment of accrued interest and fees, the opening, closure and liquidation of a CA, the computation of loss and profit, and the computation of real and weighted collateral values. For each CA, it tracks the following values in the CreditAccountInfo struct:

- debt: the amount of underlying borrowed from the liquidity pool
- cumulativeIndexLastUpdate: the value of the base interest cumulative index the last time it was updated for the CA, i.e. on opening, debt increase, or debt decrease
- cumulativeQuotaInterest: accrued interest collected on the quotas remaining to be paid
- quotaFees: sum of the fees from the increase of quota remaining to be paid
- enabledTokensMask: bitmask of enabled tokens on the CA, disabled tokens will be skipped when computing the collateral value of the CA
- flags: indicates whether the CA has pending withdrawals, and whether any bot has permission to manage the CA
- since: timestamp of the opening of the CA
- borrower: holder of the CA

All the actions done by the CM are called from the Credit Facade. The functions used to manage the state of a CA are detailed in the next section.

The parameters of the CM (allowed collateral tokens and their liquidation threshold, system's fees, quoted tokens, ...) are configured by the CreditConfigurator.

3.1.3 CreditFacade

The Credit Facade (CF) is the only entrypoint in the system to interact with the Credit Accounts. The available functions are:

- openCreditAccount: checks the debit and borrowing limits, burns the DegenNFT if the CF is in whitelisted mode, takes a free CA from the factory and initialize it with up-to-date parameters, moves the funds from the Pool to the CA, updates the cumulative index of the Pool, runs _multicall() and the full collateral check afterwards, reverts if HF < 1. It is not allowed to increase/decrease the debt within the multicall.
- closeCreditAccount: only the owner of the CA can call this function. It computes the total debt, claims the mature and immature withdrawals, and optionally interacts with adapters through a _multicall(). It erases all the permissions in the bot list, computes the amount that needs to be paid to the Pool, as well as the profit made. Pulls the underlying tokens from the owner if the CA does not have enough of it, repays the Pool and updates its cumulative index and expected liquidity. Resets all the quotas to zero and decreases the expected interest the Pool will make from the quotas. It sends the remaining tokens to the owner and returns the CA to the factory. It is important to note that it is possible to close an unhealthy CA. During the closure, both mature and immature withdrawals are claimed and sent to a specified address. These values are not accounted in the total value of the collateral held by the CA.
- liquidateCreditAccount: liquidates an undercollateralized or expired CA. It can happen in two modes: emergency and normal. During the emergency mode, only a set of whitelisted addresses can liquidate a CA. The function may first update the price feeds and then checks if HF < 1 or the CF has expired. The withdrawals are claimed or cancelled based on the mode (see WithdrawalManager for more). A _multicall() is optionally run with only calls to adapters allowed. All the bot permissions are erased. The function then proceeds to compute the amount

needed to be paid to the Pool, the profit or the loss the pool made as well as the remaining funds that should be returned to the original borrower. The rest of the funds are sent to the liquidator who earns a part of the CA s value. The system pulls underlying tokens from the liquidator if the CA does not have enough of it, repays the Pool, updates its cumulative index and expected liquidity, and burns shares of the treasury if the Pool incurs a loss. The quotas are reset for the account and the expected profit of the Pool is decreased. The CA is returned to the factory. If the Pool incurred a loss and in case the cumulative loss of CF becomes too big, the CF pauses and essentially enters an emergency mode. If the Pool incurred a loss, the limit of all the enabled quoted tokens of the CA will be set to 1. It is important to note that the pending withdrawals are not accounted in the HF but the (forced) cancelled ones are taken into account when the total value of a CA is calculated.

- `multicall`: only the owner of the CA can call this function. It calls `_multicall()` and runs the full collateral check afterward, which reverts if `HF < 1`.
- `botMulticall`: the caller must be a whitelisted bot and have permission to manage the CA. It calls `_multicall()` and runs the full collateral check afterward.
- `claimWithdrawals`: only the owner of the CA can call this function. It claims the mature withdrawals from the `WithdrawalManager` for a CA. The funds are sent to a specified address. If this transfer fails or the token is ETH, the funds are made available to the intended receiver through an immediate withdrawal.
- `setBotPermissions`: only the owner of the CA can call. Set arbitrary permissions in the bot list for an arbitrary contract address that has not been explicitly forbidden. This address will then be allowed to manage the CA given its permissions.

3.1.3.1 `_multicall()`

The `_multicall()` function is the main function to manage a CA. It can execute the following bundled actions:

- revert if some balances are lower than a given target, acts as a slippage protection
- update the price oracle
- add collateral to the CA
- update the quotas. If a quota is increased, a fee is charged based on the increased amount. The Pool revenue is updated accordingly.
- initiate a withdrawal. If the `WithdrawalManager` has no delay, send the tokens directly to the user. Otherwise, process mature withdrawals and schedule a new withdrawal if a free slot is found, revert if no slot is free. A maximum of two withdrawals can exist per CA.
- increase the debt. It pulls funds from the Pool to the CA, updates the cumulative index tracked by the CM for the CA and the cumulative index of the Pool.
- decrease the debt. It transfers funds from the CA to the Pool, and repays the total debt in the following order: quotas fees, quotas interest, base interest, debt. It updates the cumulative index tracked by the CM for the CA and updates the cumulative index of the Pool. If the debt was increased within the same multicall, the debt cannot be decreased.
- pay the management bot. Can be done only once per `_multicall()` and only by the bots.
- set custom parameters for the full collateral check, typically a higher HF limit.
- enable a token for the CA. Can only be done with non-quoted tokens.
- disable a token for the CA. Can only be done with non-quoted tokens.
- revoke adapter allowances
- use the whitelisted adapters. The CA will be set to be the active Credit Account in the CM.

After the bundle actions, the function will enforce the slippage protection, forbid any enabling of a forbidden token, and reset the active Credit Account in the `CM`.

3.1.3.2 Full Collateral Check

The full collateral check ensures that a `CA` has enough collateral value by checking that the health factor is greater or equal to `1`. The health factor (`HF`) is defined as:

$$\frac{TWV_{CA}^{USD} * price_{USD,underlying}}{TotalDebt_{CA}}$$

with `TWV` being the total weighted value of the `CA`:

$$TWV_{CA}^{USD} = \sum_{i \in eQT} \min(quota_{CA,i}^{USD}, tokenBalance_j^{USD}) * lt_i + \sum_{j \in eUT} tokenBalance_j^{USD} * lt_j$$

where `eQT` and `eUT` are the enabled quoted tokens and the enabled unquoted tokens for the `CA`, and

$$TotalDebt_{CA} = debt + baseInterest + quotasInterest + quotasFees + interestFees$$

Note: all the price conversions to USD are assumed to yield a result with 8 decimals.

3.1.4 `CreditConfigurator`

Used by the `Configurator` role to configure a `CM` and a `CF`.

On the `CM`, the `CreditConfigurator` can:

- add a new collateral token, quoted or not
- set the liquidation threshold for a token
- set a ramping liquidation threshold following a linear function during the ramping period
- set a token as quoted, enabling the quotas logic for that token
- set the two-ways mapping `adapter <--> 3rd party contract`, allowing or forbidding adapters
- set the system's fees, i.e. fee on the interest (base and quotas), normal/expired liquidation fee, normal/expired liquidation discount
- update the liquidation threshold for the underlying token
- set the price oracle
- set the Credit Facade and migrate the old parameters if necessary
- set Credit Configurator
- set the maximum number of allowed enabled tokens per `CA`

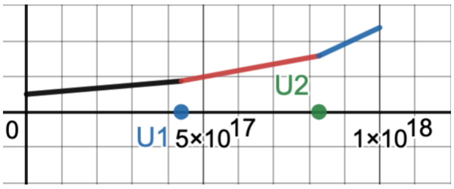
On the `CF`, the `CreditConfigurator` can:

- set the allowance for a token (`AllowanceAction.Allow` or `AllowanceAction.Forbid`). A forbidden token cannot be enabled or see its balance increase during a `multicall` in the `CF`
- set the minimum and maximum debt a `CA` can owe the liquidity pool
- forbid further borrowing by setting the `maxDebtPerBlockMultiplier` to `0`. Only the `PausableAdmin` role can do it
- set and reset the maximum cumulative loss, after which the system is paused
- set the `maxDebtPerBlockMultiplier`. Both the `Controller` and `Configurator` can do it
- set the expiration date of a `CF`. Both the `Controller` and `Configurator` can do it
- set the `BotList` address, managing the bots' permissions

- add and remove emergency liquidators, a set of whitelisted addresses that are allowed to liquidate unhealthy positions when the system is paused
- set the total debt limit, available only for old pools that do not track their debt. Both the `Controller` and `Configurator` can do it
- set the total debt parameters, available only for old pools that do not track their debt.

3.2 Pools

The pools are used to manage the liquidity of the system. Every `Pool` contract is tied to an underlying token, and users can lend funds to a `Pool` and accrue interest. The funds held by a `Pool` are then used by the users the Credit Manager. Only the whitelisted Credit Managers can borrow from the `Pool` and send the tokens to a `CA`. A `Pool` tracks the debt of each `CM` that is connected to it and will revert if the debt limit is reached on a new borrow. It also tracks it current utilization through the expected and available liquidity, and the cumulative index of the base interest. The base interest rate of a `Pool` is based on the current utilization and follows a two-point linear function like the one drawn below:



On the liquidity providers' (`LP`) side, the `Pool` implements the `ERC4626` tokenized vault standard. The `LP` can use the functions defined by `ERC4626` to provide and remove liquidity in the `Pool`, the shares' computations (`totalAssets()`) are based on the expected liquidity (`sum of all current LP positions + sum of unclaimed accrued base interest + sum of unclaimed quotas interest if the pool supports quotas`), which is an internally tracked value that does not depend on the `Pool` underlying token balance. The interface of the pool includes a `depositWithReferral` function, which as the name suggests emits an event with a referral code upon deposit.

3.3 `AccountFactory`

To reduce costs of the deployment of the Credit Accounts, an account renting system is implemented. Upon opening a credit account, a free Credit Account contract is taken from the factory. After a position's closure, the credit account is returned to the factory. A returned credit account can only be reused after a hardcoded delay of 3 days. In case all the Credit Accounts are used, a new one is created by using the cloning paradigm.

3.4 `WithdrawalManager`

The `WithdrawalManager` takes care of the Credit Accounts' tokens withdrawal. There are two types of withdrawals, scheduled and immediate.

- scheduled: when the owner of a `CA` wants to withdraw some tokens, a scheduled withdrawal is created and they must wait for a delay before the withdrawal is to be considered as mature. During the delay, the withdrawals can be processed or cancelled in three ways in addition to a normal claim:

    1. On normal liquidation: the immature withdrawals are forcibly cancelled and returned to the `CA` and their assets are accounted for in the computation of the total value of the `CA`. The mature withdrawals are forcibly claimed and sent to the initial borrower. If this transfer fails or the token is `ETH`, the funds are made available to the initial borrower through an immediate withdrawal.

2. On emergency liquidation: like on normal liquidation but the mature withdrawals are also cancelled.
3. On `CA` closure: the mature and immature withdrawals are forcibly claimed and sent to a receiver address. If this transfer fails or the token is `ETH`, the funds are made available for the receiver through an immediate withdrawal.

- immediate: for a given caller and token, the caller can immediately pull the funds to an arbitrary address

Each `CA` can have up to 2 pending scheduled withdrawals.

3.5 Quotas and `PoolQuotaKeeper`

Quotas can be used if the system wants to limit its exposure to certain tokens by considering a Credit Account's balance for a quoted token only up to the quota. A maximum quoted amount can be set per token and per pool. If users want to increase the quota of a Credit Account, they must pay a fee based on the delta amount. The interest is charged at a rate decided by the `Gauge`. On a quota increase, the sum of the quoted amounts for a given token and for a given `Pool` cannot go over the maximum quoted amount for that token and that `Pool`. The accounting and limits for quotas are managed by the `PoolQuotaKeeper` (`PQK`) contract. There is one `PQK` per `Pool`. Quoted tokens are activated by the `Configurator` role.

3.6 Gauges

The `Gauge` contract holds the accounting of the votes of stakers that voted on the attached `Pool`, and computes the rates that will be applied for each quoted token, based on the votes. There is one `Gauge` per `Pool`. Only the attached voter contract (`GearStakingV3`) is allowed to update the votes accounting with the `vote` and `unvote` functions. When a quoted token is activated on the `Gauge`, one must also set $\mathtt{rate}_{min}$ and $\mathtt{rate}_{max}$ for that token. Stakers can either vote for $\mathtt{rate}_{min}$ or $\mathtt{rate}_{max}$, i.e. LP side or CA side. The `PQK` can be triggered to read the `Gauge` at the start of every new staking epoch to update the rates applied by the system to the quoted tokens of a `Pool`. The rate for each token is computed by the following formula:

$$rate_{min} + (rate_{max} - rate_{min}) * \frac{votesLpSide}{votesLpSide + votesCaSide}$$

The voter contract can be changed by the `Configurator` role. Quoted tokens can be activated on a `Gauge` by the `Configurator` role. The $\mathtt{rate}_{min}$ and $\mathtt{rate}_{max}$ for each token can be changed by `Configurator` role, and the effect on the system will be visible starting from the next epoch.

3.7 Staking

Users of Gearbox V3 Core can stake their GEAR tokens in `GearStakingV3` and vote to agree on the interest rate that will be applied to the quoted tokens. A vote only counts once, i.e. one vote for the rate of one quoted token on one `Pool`. Once a withdrawal has been initiated, there is a time lock of 4 epochs before stakers can claim their GEAR tokens. The following functions are available for users:

- `deposit`: pull and stake GEAR tokens from the caller and optionally dispatch the voting power on one or more whitelisted `Gauge` contracts. The possible actions are voting and unvoting on the target `Gauge` contract.
- `multivote`: dispatch the voting power on one or more whitelisted `Gauge` contract. The possible actions are voting and unvoting on the target `Gauge` contract.

- `withdraw`: optionally dispatch the voting power and then initiate a withdrawal. The amount will be locked for the following 4 epochs before the withdrawal is mature. The withdrawn amount cannot be used to vote during the time lock period.
- `claimWithdrawals`: claim mature withdrawals and return GEAR tokens to the caller.

Each target contract can be assigned one of the following statuses: `Not_Allowed`, `Allowed` or `Unvote_Only`. The default status is `Not_Allowed`.

The `Configurator` role can update the status of the target contracts.

3.8 Bots service

It is possible for the `CA` owners to register to a bot service to manage their `CA` through the `CF`. The owner of a `CA` must first deposit some `ETH` in the `BotListV3` contract. Then, they can manage permissions for arbitrary, non system-forbidden contracts, that can manage the `CA`, following the permissions. The bot is also allowed to take payment for its actions. The borrowers can set limits (`CreditFacade.setBotPermissions()`) for how much the bots are allowed to take as payment: an overall limit amount `fundingAmount` that is consumed until it reaches zero, and a weekly spending allowance that is automatically reset every 7 days.

Upon account closure or liquidation, all the permissions are revoked from the `BotListV3` for the involved `CA`. Users can withdraw the remaining funds from the contract at any time.

3.9 Timelock Controller

This contract is the entry point for most of the system setters. The general flow implemented is the following:

1. A whitelisted user submits a transaction that sets a system parameter. A transaction specifies the *target* contract, the *signature* of the method to be executed, and the parameters (*data*) to be passed as arguments.
2. The parameters are sanitized.
3. The transaction is added to the transaction queue.
4. After the required time has elapsed, and within a grace period, the submitter of transaction can execute it.

Each transaction is associated with a policy hash. A user can submit a new transaction if they are the admins of that policy hash. A transaction can be cancelled by the *vetoAdmin*.

3.10 Adapters

Adapters facilitate interaction with third-party protocols using the Credit Accounts' funds. The interactions with the adapters are done through the `CreditFacade._multicall` function. Adapters are convered in the Gearbox V2.1.

3.11 Trust model

The system defines the following roles:

- Controller: This is a less powerful role that is expected to set less crucial system parameters. It is set by the configurator. The controller is allowed to set:

  - the quota limits for the tokens
  - the fees for the quota increase
  - the total debt limit of the pool
  - the debt limit for each credit manager
  - the withdrawal fee for the liquidity providers
  - the ramp liquidation threshold
  - forbid adapters
  - the min and the max debt limit for the credit accounts
  - the max debt per block multiplier
  - the expiration date of the controller
  - the total debt limit of the facade

- Configurator: This is the most powerful role. It can configure most system parameters. This role should be controlled by the Gearbox DAO. The configurator can be updated only by the configurator itself. The initial configurator is the deployer of the contracts. The configurator is allowed to set the parameters which are not set by the controller.
- (Un)PausableAdmins: These are accounts that are allowed to pause or unpause the system. They are set by the configurator who also is the first pausable admin. The pausable admin can also forbid a token.
- Emergency liquidator: This is an address that is allowed to liquidate credit accounts when the system is paused. The configurator can set this account.
- Veto Admin: They are allowed to cancel a transaction that updates some of the system parameters. The veto admin is set by the configurator.

The aforementioned are considered fully trusted and expected to never act maliciously.

- End users: Any user can be a liquidity provider or a borrower who controls a credit account.

Moreover, there are components of the system which are considered trusted:

- The price oracles are assumed to always return the correct prices and in the correct format. In particular, the USD prices of the tokens should always have 8 decimals.
- The external contracts with which the system interacts e.g., through the adapters are considered trusted.

The contracts are not upgradeable.

3.12 Changes in Version 2

- There is a maximum of 5 bots that can be approved for a `CreditAccount`.
- The function `mintWithReferral` has been added in the `PoolV3`.

4 Limitations and use of report

Security assessments cannot uncover all existing vulnerabilities; even an assessment in which no vulnerabilities are found is not a guarantee of a secure system. However, code assessments enable the discovery of vulnerabilities that were overlooked during development and areas where additional security measures are necessary. In most cases, applications are either fully protected against a certain type of attack, or they are completely unprotected against it. Some of the issues may affect the entire application, while some lack protection only in certain areas. This is why we carry out a source code assessment aimed at determining all locations that need to be fixed. Within the customer-determined time frame, ChainSecurity has performed an assessment in order to discover as many vulnerabilities as possible.

The focus of our assessment was limited to the code parts defined in the engagement letter. We assessed whether the project follows the provided specifications. These assessments are based on the provided threat model and trust assumptions. We draw attention to the fact that due to inherent limitations in any software development process and software product, an inherent risk exists that even major failures or malfunctions can remain undetected. Further uncertainties exist in any software product or application used during the development, which itself cannot be free from any error or failures. These preconditions can have an impact on the system's code and/or functions and/or operation. We did not assess the underlying third-party infrastructure which adds further inherent risks as we rely on the correct execution of the included third-party technology stack itself. Report readers should also take into account that over the life cycle of any software, changes to the product itself or to the environment in which it is operated can have an impact leading to operational behaviors other than those initially determined in the business specification.

5 Terminology

For the purpose of this assessment, we adopt the following terminology. To classify the severity of our findings, we determine the likelihood and impact (according to the CVSS risk rating methodology).

- *Likelihood* represents the likelihood of a finding to be triggered or exploited in practice
- *Impact* specifies the technical and business-related consequences of a finding
- *Severity* is derived based on the likelihood and the impact

We categorize the findings into four distinct categories, depending on their severity. These severities are derived from the likelihood and the impact using the following table, following a standard risk assessment procedure.

Likelihood	Impact		
	High	Medium	Low
High	Critical	High	Medium
Medium	High	Medium	Low
Low	Medium	Low	Low

As seen in the table above, findings that have both a high likelihood and a high impact are classified as critical. Intuitively, such findings are likely to be triggered and cause significant disruption. Overall, the severity correlates with the associated risk. However, every finding's risk should always be closely checked, regardless of severity.

6 Findings

In this section, we describe any open findings. Findings that have been resolved have been moved to the Resolved Findings section. The findings are split into these different categories:

- Design: Architectural shortcomings and design inefficiencies
- Correctness: Mismatches between specification and implementation

Below we provide a numerical overview of the identified findings, split up by their severity.

Critical-Severity Findings	1

- Anyone Can Redistribute the Votes

High-Severity Findings	0

Medium-Severity Findings	0

Low-Severity Findings	1

- Arbitrary Bot Permissions Risk Accepted

6.1 Anyone Can Redistribute the Votes

Design Critical Version 2

CS-GEARV3CORE-001

The function `GearStakingV3.deposit` allows anyone to deposit GEAR tokens and execute a multivote for an arbitrary address `to`. The unrestricted call to `_multivote` in the name of `to` allows the caller to redistribute the votes of any `to` target address in the limits of `totalStaked`.

6.2 Arbitrary Bot Permissions

Design Low Version 1 Risk Accepted

CS-GEARV3CORE-002

When setting permissions to a bot, the `permissions` are not sanitized, and it is thus possible to set arbitrary permissions that could be meaningless in the Gearbox system.

Risk accepted:

Gearbox Protocol responded:

```
Most importantly, permissions are typed as uint192, which
ensures that users can't affect the behaviour of the multicall by changing flags (higher
bits of the flags argument of _multicall).
```

7 Resolved Findings

Here, we list findings that have been resolved during the course of the engagement. Their categories are explained in the Findings section.

Below we provide a numerical overview of the identified findings, split up by their severity.

Critical-Severity Findings	0
High-Severity Findings	0
Medium-Severity Findings	1

- Too Many Bots Can Block Liquidation Code Corrected

Low-Severity Findings	5

- Global Quoted Tokens Mask Instead of Credit Account's Mask Code Corrected
- Mint With Referral Code Corrected
- Missing Input Sanitization Code Corrected
- Quota Increase Is Allowed for Forbidden Tokens Code Corrected
- Updating Voter Contract May Lock GEAR Code Corrected

7.1 Too Many Bots Can Block Liquidation

Design Medium Version 1 Code Corrected

CS-GEARV3CORE-016

It is possible to block a liquidation by adding enough bots so that erasing all the bot's permission on liquidation would be bigger than the block gas limit, thus blocking the liquidation process.

If such a scenario happens, a new `BotList` can always be redeployed and re-linked to the system, but all the bot users will have to withdraw their funds from the old `BotList` and set all the permissions again.

Code corrected:

A global limit of 5 bots per credit account has been added. More specifically `CreditFacade.setBotPermissions` reverts if the number of remaining bots exceeds the global limit.

7.2 Global Quoted Tokens Mask Instead of Credit Account's Mask

Correctness Low Version 1 Code Corrected

CS-GEARV3CORE-010

The specification of `CreditManagerV3._getQuotedTokensData()` specifies that the returned value `_quotedTokensMask` should be the mask of the enabled quoted tokens of the Credit Account, but the actual returned value is the mask of all the quoted tokens in the Credit Manager.

Specification updated:

The nat spec has been updated to reflect the functionality of the code.

7.3 Mint With Referral

Design | Low | Version 1 | Code Corrected

CS-GEARV3CORE-013

In the `PoolV3`, the function `depositWithReferral` is available for users, but there is no such equivalent for `mint`.

Code corrected:

The function `mintWithReferral` has been added in the `PoolV3`.

7.4 Missing Input Sanitization

Design | Low | Version 1 | Code Corrected

CS-GEARV3CORE-011

None of the `setMaxEnabledTokens()` functions check that the new `maxEnabledTokens` is greater than zero. Setting zero as `maxEnabledTokens` would make the system unusable.

Code corrected:

The function `CreditConfigurator.setMaxenabledTokens` has been updated and reverts if the new value for `maxEnabledTokens` is `0`.

7.5 Quota Increase Is Allowed for Forbidden Tokens

Design | Low | Version 1 | Code Corrected

CS-GEARV3CORE-017

When a `CA` holds a forbidden enabled token, it is not allowed to increase its debt or the balance of such a token. However, the system allows the increase of the quota of an enabled forbidden token. While it does not increase the exposure of the system to the problematic token, it would make sense to disallow such quota updates for consistency.

Code corrected:

`CreditFacade._updateQuota` reverts when a forbidden token is specified in `callData`.

7.6 Updating Voter Contract May Lock GEAR

Design | Low | Version 1 | Code Corrected

CS-GEARV3CORE-014

Changing the voter contract of a `Gauge` while stakers still have registered votes may break the votes accounting and prevent stakers from withdrawing their funds from the voter contract.

Code corrected:

The `voter` contract of a `Gauge` has been updated to be `immutable`.

7.7 Code Duplication

Informational | Version 1 | Code Corrected

CS-GEARV3CORE-009

1. The computation of the value `pctDiff` in `PolicyManagerV3._checkPolicy()` is duplicated
2. The computation `timestampRampStart + rampDuration` in `CreditLogic.getLiquidationThreshold()` is duplicated

Code corrected:

Code duplication has been removed.

7.8 Gas Optimizations

Informational | Version 1 | Code Corrected

CS-GEARV3CORE-006

1. The computations in `GearStakingV3.getCurrentEpoch()` can be `unchecked`.
2. The computations of the new `withdrawalsPerEpoch` in `GearStakingV3.withdraw` can be `unchecked`.
3. Disabling the token outside of the `if` block in `CollateralLogic.calcNonQuotedTokensCollateral()` is redundant. There is no need to disable already disabled tokens.
4. In the function `CreditLogic.calcDecrease`, the condition `amountToRepay > quotaFees` could be transformed into a non-strict inequality to save a bit of gas since `SafeCast` will not be needed.
5. Assigning to `newDebt` and `newCumulativeIndex` in the branch `amountToRepay < cumulativeQuotaInterest + quotaProfit` of `CreditLogic.calcDecrease()` has no effect since they will be reassigned later in the function.
6. The mapping `AccountFactoryV3._queuedAccounts` could use a static array instead of a dynamic array. Its length is never read and there would not be the need for updating the length of a static array.
7. In `CollateralLogic.calcCollateral()`, one could use the first pass over the enabled token mask combined with the collateral hints on the quoted tokens, and use that information to optimize

the pass on the unquoted tokens so `CollateralLogic.calcNonQuotedTokensCollateral()` does not have to iterate through the whole mask until it finds the last token.

8. The function `PoolQuotaKeeperV3._updateQuota` does not implements the gas optimization trick of leaving `1 wei` when the quota is manually reduced to `0`.

Code corrected:

1. The computations have been moved in an `unchecked` block.
2. The total supply of `GEAR` (`10_000_000_000e18`) would fit in `type(uint96).max`, thus an overflow check is not needed.
3. The line `tokensToCheckMask = tokensToCheckMask.disable(tokenMask);` could be moved into the preceding `if` block to save gas. If done outside of the block, this line will be executed even for the `tokenMask` that are already disabled in the `tokensToCheckMask`.
4. The use of `SafeCast` has been removed from the `else` branch.
5. The redundant assignments have been removed.
6. The mapping has been updated to use a static array of size `2**32`.
7. This issue does not arise with a well formatted `collateralHints`, Gearbox Protocol expects well formatted `collateralHints`.
8. Gearbox Protocol specified that the optimization will be done at the UI level.

7.9 Inconsistent Overflow Handling

Informational | Version 1 | Code Corrected

CS-GEARV3CORE-015

`USDTFees.amountUSDTWithFee` handles the case where `maximumFee + amount` overflows. However, there is no such a case when the `amountWithBP` is calculated. This is just an inconsistency issue as it is unlikely the `amount` value to be that big.

Code corrected:

An operation which is less probable to overflow is currently used.

7.10 Inconsistent Remaining Balance Check

Informational | Version 1 | Code Corrected

CS-GEARV3CORE-005

Different checks are implemented for checking if an amount is `0` or `1`, `amount < 2` or `amount <= 1`. It is recommended to always use the same way of checking for consistency and code maintainability.

Code corrected:

All the checks mentioned above have been updated to be `<= 1` in the codebase.

7.11 Redundant and Missing Events Emission

Informational Version 1 Code Corrected

CS-GEARV3CORE-012

There are multiple instances of setter functions where events are emitted regardless of whether they actually change the values. More specifically:

1. `GaugeV3.setVoter`
2. `GaugeV3.changeQuotaTokenRateParams`
3. `GearStakingV3.setVotingContractStatus`

Furthermore, an event is not emitted in `PolicyManagerV3.setPolicy`.

Code corrected:

1. The function `setVoter` and event `SetVoter` have been removed.
2. The function `GaugeV3._changeQuotaTokenRateParams` has been updated to early return and not emit any event if the updated values are the same as the old values.
3. The function `GearStakingV3.setVotingContractStatus` has been updated to early return and not emit any event if the updated value is the same as the old value.

Events have been added in `PolicyManagerV3.setPolicy()`, `PolicyManagerV3.disablePolicy()`, and `PolicyManagerV3.setGroup()`.

7.12 Unused Code

Informational Version 1 Code Corrected

CS-GEARV3CORE-007

The immutable `GaugeV3.addressProvider` is set but never used.

Code corrected:

`addressProvider` has been removed.

7.13 Wrong Comments

Informational Version 1 Code Corrected

CS-GEARV3CORE-008

1. `USDT_Transfer._amountUSDTMinusFee()`: the value returned by the function is what the recipient would receive if `amount` was sent, not how much to send to reach `amount`
2. `USDTFees.amountUSDTMinusFee()`: the value returned by the function is what the recipient would receive if `amount` was sent, not how much to send to reach `amount`

3. `CreditFacadeV3._revertIfOutOfTotalDebtLimit()`: `totalDebtLimit = totalDebt.currentTotalDebt` should be `totalDebtLimit = totalDebt.totalDebtLimit`
4. `CreditManagerV3.calcDebtAndCollateral()`: `Therefore, it is prevented from being called internally` should be `Therefore, it is prevented from being called externally`

Code corrected:

Comments for 1. and 2. were fixed.

8 Informational

We utilize this section to point out informational findings that are less severe than issues. These informational issues allow us to point out more theoretical findings. Their explanation hopefully improves the overall understanding of the project's security. Furthermore, we point out findings which are unrelated to security.

8.1 Interest Accrued by Quota Dust

Informational **Version 1** **Risk Accepted**

CS-GEARV3CORE-004

For gas optimization reasons, the Credit Accounts quotas are reset to `1`, and this `1 wei` contributes to `TokenQuotaParams.totalQuoted`. This dusty `wei` has multiple effects:

- this `1 wei` may contribute to the pool's revenue on `updateRates` because it's based on `TokenQuotaParams.totalQuoted`, which sums up that dust.
- if a CA was closed and leaves `1 wei` of quoted `tokenA` in `AccountQuota.quota`, the next borrower that increases the quota for that `tokenA` on the same CA may have some interests due because the `timeDelta * currentQuotedTokenRate` combination may be enough so that `calcAccruedQuotaInterest` may return a non zero value, recall that the minimal period before one can reuse a CA is 3 days (259200 seconds).
- if this quota is not reactivated for a long time, over multiple CA open and close cycles, the time delta between now and the last time the `accountQuota.cumulativeIndexLU` was updated can be significant.

Note, the above is a theoretical issue and mostly an inconsistency of the system and it is not expected to harm the users. It can happen that the pool revenue accounts for the `1 wei` due to the reason above, but the computation in `calcAccruedQuotaInterest` yields 0.

8.2 Missing Natspec

Informational **Version 1**

CS-GEARV3CORE-003

Some of the natspec are missing or incomplete, here is a non-exhaustive list:

1. `CreditFacadeV3.setDebtLimits()`: natspec for parameter `_maxDebtPerBlockMultiplier` is missing
2. `CreditManagerV3.closeCreditAccount()`: natspect for parameter `collateralDebtData` is missing
3. `QuotasLogic.cumulativeIndexSince()`, `QuotasLogic.calcAdditiveCumulativeIndex()` and `QuotasLogic.calcAccruedQuotaInterest()`: natspec for the return value are missing
4. `USDTFees`: the library is missing natspec
5. `BitMask`: the library is missing natspec for return values and the `calcIndex` function
6. `CollateralLogic.calcQuotedTokensCollateral()`: natspec for parameters `quotedTokens` and `quotasPacked` are missing

Gearbox Protocol said:

```
We're preparing a system-wide cleanup of NatSpec and comments.
```

9 Notes

We leverage this section to highlight further findings that are not necessarily issues. The mentioned topics serve to clarify or support the report, but do not require an immediate modification inside the project. Instead, they should raise awareness in order to improve the overall understanding.

9.1 Credit Account Owners Must Be Able to Manage the Underlying Token

Note Version 1

When normally closing a credit account, its owner can specify the receiver of its funds. This is also true when funds are directly claimed in the withdrawal manager. However, the receiver of the remaining funds cannot be specified upon liquidation and defaults to the owner of the Credit Account which must be able to manage the underlying tokens when they're directly transferred or sent by the `WithdrawalManager`. If not, the remaining funds will be lost.

9.2 Fees Parameters

Note Version 1

It is important that the fees are set correctly for the system to behave as expected. If fees are misconfigured, it could happen that certain unexpected behaviors may take place, for example, holders of unhealthy Credit Accounts could be incentivized to close their positions instead of liquidating themselves.

9.3 Quota Activation Can Make Credit Accounts Unhealthy

Note Version 1

The activation of quota for a previously whitelisted token in the Credit Manager can make Credit Accounts using that token as active collateral liquidatable, since their quotas will be `0`.

9.4 Quotas Are Independant Of Collateral

Note Version 1

A credit account can increase its quotas by consuming all the available amount, independently of its collateral. Moreover, this could make the credit account very quickly liquidatable as the quota interest will be significant.

9.5 Supported Tokens

Note Version 1

- The system only supports standard `ERC20` tokens without special behaviors, especially tokens with callbacks (`ERC777`) which would allow arbitrary code execution. More explicitly, tokens with two entry points should also be avoided.
- The LP token of the `Pool` should not be allowed as collateral in the system.
- Added tokens should be reviewed regarding gas consumption. For example, the function `UnsafeERC20._unsafeCall` allows the callee to return a memory pointer that, if far in memory, would incur a huge gas cost for memory allocation.