



GEARBOX

Gearbox v2.0
Smart Contract Security Assessment

Version: 1.1

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Introduction

Sigma Prime was commercially engaged to perform a time-boxed security review of the Gearbox smart contracts. The review focused solely on the security aspects of the Solidity implementation of the contract, though general recommendations and informational comments are also provided.

Disclaimer

Sigma Prime makes all effort but holds no responsibility for the findings of this security review. Sigma Prime does not provide any guarantees relating to the function of the smart contract. Sigma Prime makes no judgements on, or provides any security review, regarding the underlying business model or the individuals involved in the project.

Document Structure

The first section provides an overview of the functionality of the Gearbox smart contracts contained within the scope of the security review. A summary followed by a detailed review of the discovered vulnerabilities is then given which assigns each vulnerability a severity rating (see [Vulnerability Severity Classification](#)), an *open/closed/resolved* status and a recommendation. Additionally, findings which do not have direct security implications (but are potentially of interest) are marked as *informational*.

Outputs of automated testing that were developed during this assessment are also included for reference (in the Appendix: [Test Suite](#)).

The appendix provides additional documentation, including the severity matrix used to classify vulnerabilities within the Gearbox smart contracts.

Overview

Gearbox is a generalised leverage protocol, which gives access to undercollateralised lending through an entirely new credit account primitive. Credit accounts enable the extension of credit to borrowers which is not built upon a reputation system, or "credit score".

Credit accounts consist of two types of collateral:

- Initial funds provided by the borrower when they open their credit account.
- Borrowed funds that are provided by the protocol's pool service.

Borrowers are able to utilise funds from liquidity providers to interact with a subset of trusted protocols. These interactions are accessible through various adapters which prevent funds from maliciously exiting the borrower's credit account.

Gearbox 2.0 introduces several new changes to the previous iteration:

- Upgrades legacy contracts to Solidity v0.8.

- Improves liquidation flows.
- Introduces multical functionality for running batches of transactions through a credit account.
- Utilises USD price fees instead of ETH.

Liquidity providers earn yield on the fees generated by the Gearbox ecosystem. Upon closure or liquidation of the credit account, the borrowed funds are returned to the pool alongside any interest and fees accrued on the duration of the loan.

Security Assessment Summary

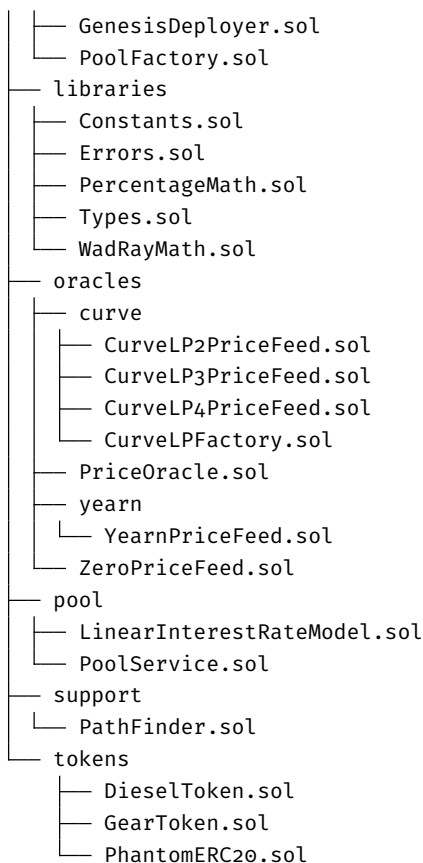
This review was conducted on the files accessed from a private Gearbox 2.0 repository. This repository was under active development by the Gearbox team during review, and four commit hashes were targeted throughout the course of the review.

The following commit hashes detail the targets (ordered with respect to time):

- [432a213](#)
- [6c2bcd](#)
- [5d4ec27](#)
- [0f500f0](#)

The final scope of the review included the following files:

```
— adapters
  — convex
    — ConvexV1_BaseRewardPool.sol
    — ConvexV1_Booster.sol
    — ConvexV1_ClaimZap.sol
    — ConvexV1_StakedPositionToken.sol
  — curve
    — CurveV1_2.sol
    — CurveV1_3.sol
    — CurveV1_4.sol
    — CurveV1_Base.sol
    — CurveV1_stETHGateway.sol
    — CurveV1_stETH.sol
  — lido
    — LidoV1.sol
    — LidoV1_WETHGateway.sol
  — uniswap
    — UniswapV2.sol
    — UniswapV3.sol
  — yearn
    — YearnV2.sol
— core
  — AccountFactory.sol
  — ACL.sol
  — ACLTrait.sol
  — AddressProvider.sol
  — ContractsRegister.sol
  — DataCompressor.sol
  — WETHGateway.sol
— credit
  — CreditAccount.sol
  — CreditConfigurator.sol
  — CreditFacade.sol
  — CreditManager.sol
— factories
  — CreditManagerFactory.sol
```



Note: third party libraries and dependencies were excluded from the scope of this assessment.

The manual code review section of the report focused on identifying any and all issues/vulnerabilities associated with the business logic implementation of the contracts. Specifically, their internal interactions, intended functionality and correct implementation with respect to the underlying functionality of the Ethereum Virtual Machine (for example, verifying correct storage/memory layout). Additionally, the manual review process focused on all known Solidity anti-patterns and attack vectors. These include, but are not limited to, the following vectors: re-entrancy, front-running, integer overflow/underflow and correct visibility specifiers. For a more thorough, but non-exhaustive list of examined vectors, see [?, ?].

To support this review, the testing team used the following automated testing tools:

- Mythril: <https://github.com/ConsenSys/mythril>
- Slither: <https://github.com/trailofbits/slither>
- Surya: <https://github.com/ConsenSys/surya>

Output for these automated tools is available upon request.

Findings Summary

The testing team identified a total of 21 issues during this assessment. Categorised by their severity:

- Critical: 4 issues.
- High: 4 issues.
- Medium: 7 issues.
- Low: 3 issues.
- Informational: 3 issues.

Detailed Findings

This section provides a detailed description of the vulnerabilities identified within the Gearbox smart contracts. Each vulnerability has a severity classification which is determined from the likelihood and impact of each issue by the matrix given in the Appendix: [Vulnerability Severity Classification](#).

A number of additional properties of the contracts, including gas optimisations, are also described in this section and are labelled as “informational”.

Each vulnerability is also assigned a **status**:

- **Open:** the issue has not been addressed by the project team.
- **Resolved:** the issue was acknowledged by the project team and updates to the affected contract(s) have been made to mitigate the related risk.
- **Closed:** the issue was acknowledged by the project team but no further actions have been taken.

Summary of Findings

ID	Description	Severity	Status
GRB-01	Incorrect Parsing of Token Path Between Gearbox and Uniswap	Critical	Resolved
GRB-02	Liquidators Can Manipulate Pool's Profit or Loss Values	Critical	Resolved
GRB-03	Denial-of-Service (DoS) by Opening a Credit Account on Behalf of the CreditFacade Contract	Critical	Resolved
GRB-04	Liquidation Avoidance through Rejecting Native Ether Transfers	Critical	Resolved
GRB-05	Incomplete Implementation of Native Ether Transfers in LidoV1_WETHGateway	High	Open
GRB-06	extraReward2 is Not Set in the constructor()	High	Open
GRB-07	Liquidation Avoidance by Front-Running liquidateCreditAccount() with Ownership Transfer	High	Open
GRB-08	approve() Will Revert on Any Credit Account	High	Resolved
GRB-09	Tokens Passed in Incorrect Order when Calling fastCollateralCheck()	Medium	Open
GRB-10	Incorrect Construction of stakedPhantomToken	Medium	Open
GRB-11	Premature Self-Destruct of PoolFactory	Medium	Open
GRB-12	Incorrect Token Amounts Used in add_liquidity()	Medium	Open
GRB-13	Incorrect Account Address Results in Missed Rewards	Medium	Open
GRB-14	Flashloan Protection Bypass Through Debt Increase and Account Closure Within The Same Block	Medium	Open
GRB-15	Chainlink Oracle Data Feeds Lack Validation	Medium	Open
GRB-16	Curve Adapters May Fail to Enable Tokens if a Zeroised min_amounts Array is Provided	Low	Open
GRB-17	Credit Accounts Can Pass a Full Collateral Check and Also be Liquidatable	Low	Open
GRB-18	Calls to calcBorrowRate() Can Fail if Variable is Set Incorrectly	Low	Open
GRB-19	Credit Accounts May be Returned with Residual Assets	Informational	Open
GRB-20	Incorrect creditConfigurator Upgrades Will Lock Configuration	Informational	Open
GRB-21	Miscellaneous Gearbox General Comments	Informational	Open

GRB-01	Incorrect Parsing of Token Path Between Gearbox and Uniswap		
Asset	contracts/adapters/uniswap/UniswapV3.sol		
Status	Resolved: See Resolution		
Rating	Severity: Critical	Impact: High	Likelihood: High

Description

Note, this issue was also disclosed for the Gearbox V1 deployment via Immunifi's bug bounty program during the course of this review. It is further detailed in this [post-mortem](#).

It is possible to manipulate parameters passed in to `exactOutput()` function of `UniswapV3.sol` adapter to bypass collateral health check, what may lead to theft of funds from the pool.

Gearbox protocol makes use of various adapters allowing borrowers to interact with a subset of trusted protocols, including Uniswap. The `UniswapV3.sol` contract allows users to swap `tokenIn` tokens for `tokenOut` tokens. A collateral health check is performed on the total input/output USD value, preventing funds from exiting the borrower's credit account.

Malicious borrowers are able to craft a path parameter passed in the `exactOutput()` such that `tokenIn` is not used by Uniswap, bypassing the `fastCollateralCheck()` call.

The `_exactOutput()` function parses the first 20 bytes as `tokenOut` and the last 20 bytes as `tokenIn`. However, Uniswap parses `tokenIn` by taking an offset of 23 bytes. As a result, a malicious parameter could consist of `abi.encodePacked(WBTC, poolFee, WETH, DAI)` which results in collateral check performed on a DAI -> WBTC swap, instead of WETH -> WBTC.

The way Uniswap decodes single-hop paths, can be broken down into the following:

- The first 20 bytes represent `tokenOut`.
- The next 3 bytes details the fee charged by the pool.
- The last 20 bytes represent `tokenIn`.

Multi-hop token swaps add 23 bytes to the path length for each additional hop, consisting of 20 bytes for the intermediary token and 3 bytes for the fee charged by the pool.

By deploying a fake ERC20 token and creating a pool for it on Uniswap, an attacker can force a credit account to trade at an unfair price while still passing all of Gearbox's health and safety checks. The attacker is able to withdraw the stolen tokens by minting fake ERC20 tokens and trading these against their own liquidity pool.

Recommendations

Validate that Gearbox decodes `params.path` the same way as seen in Uniswap's `SwapRouter.exactOutput()` implementation. Careful consideration needs to be made to ensure that the correct byte offset is applied to `tokenIn` when performing multi-hop token swaps.

Resolution

The development team has implemented a fix addressing this issue in commit [fa877cc](#).

GRB-02	Liquidators Can Manipulate Pool's Profit or Loss Values		
Asset	contracts/credit/CreditFacade.sol		
Status	Resolved: See Resolution		
Rating	Severity: Critical	Impact: High	Likelihood: High

Description

Liquidators can manipulate the protocol's profit and loss accounting in `CreditFacade.liquidateCreditAccount()`, which can lead to theft of funds from the pool.

The call to `_multicall()` is done after `totalValue` is calculated. Hence, if a liquidator borrows additional funds before closing the target credit account, `totalValue` will be under-represented in comparison to `borrowedAmountWithInterest`.

This causes `CreditManager._calcClosePaymentsPure()` to miscalculate the `loss` amount as `amountToPool >= totalFunds`, which means `amountToPool = totalFunds`. The `totalFunds` will be less than `borrowedAmountWithInterest`, therefore the `loss` amount will be calculated as `borrowedAmountWithInterest - amountToPool`.

This vulnerability allows an attacker to continually burn diesel tokens held by the treasury at no cost to the attacker. The attacker can recover the tokens that they added to the borrower account.

Recommendations

Alter the logic of `CreditManager._calcClosePaymentsPure()` to reliably compute correct payment amounts in the case of liquidations.

Resolution

The development team has mitigated this issue in commit [bdbabc](#).

GRB-03	Denial-of-Service (DoS) by Opening a Credit Account on Behalf of the CreditFacade Contract		
Asset	contracts/credit/CreditFacade.sol		
Status	Resolved: See Resolution		
Rating	Severity: Critical	Impact: High	Likelihood: High

Description

Malicious actors can create a Denial-of-Service (DoS) condition on the Gearbox protocol by opening new `creditAccount` on behalf of `creditFacade`.

The `multicall()` functionality of a `creditAccount` temporarily transfers account ownership to `creditFacade` to call various functions on behalf of the owner. There is an assertion in `CreditManger.transferAccountOwnership()` which requires that the address receiving ownership does not have an open credit account.

This assertion creates a vulnerability to a denial-of-service attack in which the attacker opens a `creditAccount` on behalf of the `creditFacade`. The `creditFacade` would then be considered a registered owner of a `creditAccount` and any attempts to receive temporary ownership of accounts via `multicall()` will fail.

Consequently, any other calls utilizing `multicall()` will fail (calls to adapters, closures and liquidations, etc).

Recommendations

Implement additional checks within `CreditFacade.openCreditAccount()` to ensure that the new credit account is not opened on behalf of a `creditFacade`.

Resolution

The development team has mitigated this issue in commit [5d4ec27](#).

GRB-04	Liquidation Avoidance through Rejecting Native Ether Transfers		
Asset	contracts/credit/CreditFacade.sol		
Status	Resolved: See Resolution		
Rating	Severity: Critical	Impact: High	Likelihood: High

Description

Borrowers can avoid liquidations by creating `CreditAccount` from a contract address that reverts every time it receives native ETH transfers.

Gearbox is designed as a composable DeFi protocol. Therefore, it is possible to open a `CreditAccount` from a contract address.

This may create issues when `CreditManager.closeCreditAccount()` attempts to convert `remainingFunds` into native ETH and transfer them to the borrower, when the underlying token is WETH. Malicious borrowers could cause `WETHGateway.unwrapWETH()` to revert by having the `receive()` function of a borrowing contract actively revert.

This vulnerability could be exploited to avoid liquidations indefinitely.

Recommendations

Remove the option to unwrap WETH when transferring any remaining funds to the borrower. This can be implemented under the following adjustment:

```
// transfer remaining funds to borrower [Liquidation case only]
if (remainingFunds > 1) {
    _safeTokenTransfer(
        creditAccount,
        underlyingToken,
        borrower,
        remainingFunds,
        false
    ); // F:[CM-14, 16]
}
```

Resolution

The development team has mitigated the issue by not allowing unwrapping WETH when transferring any remaining funds from the liquidation to the borrower. This is addressed in commit [fb616cc5](#).

GRB-05	Incomplete Implementation of Native Ether Transfers in LidoV1_WETHGateway		
Asset	contracts/adapters/lido/LidoV1_WETHGateway.sol		
Status	Open		
Rating	Severity: High	Impact: Medium	Likelihood: High

Description

LidoV1_WETHGateway.sol is missing payable receive() function and does not attach native ETH amount to submit() function calls of stETH token. As such, any call to this adapter attempting to unwrap WETH tokens will revert.

Gearbox credit accounts cannot hold native Ether for security reasons. As such, the LidoV1_WETHGateway.sol contract helps to facilitate native Ether deposits into the Lido platform by unwrapping WETH tokens before calling the submit() function.

Due to missing functionality of handling native ETH transfers, this adapter will always revert.

Recommendations

Update submit() such that the native Ether amount is passed alongside the function call.

Add payable receive() function to accept incoming ETH transfers.

GRB-06	extraReward2 is Not Set in the constructor()		
Asset	contracts/adapters/convex/ConvexV1_BaseRewardPool.sol		
Status	Open		
Rating	Severity: High	Impact: Medium	Likelihood: High

Description

`_extraReward2` is never set in the constructor of `ConvexV1_BaseRewardPool.sol`.

Gearbox integrates the Convex platform by allowing borrowers to stake their Convex LP tokens. Gearbox makes use of a phantom ERC20 token to represent the borrower's position in the reward pool. Extra rewards can be attached to a reward pool on top of any Curve and Convex rewards.

Within the `constructor()` code, `_extraReward2` is never set and will end up storing the zero address. As a result, `extraReward2` will also contain the zero address and `extraReward1` will be overwritten with the address intended for `extraReward2`. The affected code is shown below:

```
if (extraRewardLength >= 1) {
    _extraReward1 = IRewards(
        IBaseRewardPool(_baseRewardPool).extraRewards(0)
    ).rewardToken();

    if (extraRewardLength >= 2) {
        _extraReward1 = IRewards(
            IBaseRewardPool(_baseRewardPool).extraRewards(1)
        ).rewardToken();
    }
}
```

Recommendations

Modify the `constructor()` code to store the extra rewards in their correct, corresponding variables `_extraReward1` and `_extraReward2`.

GRB-07	Liquidation Avoidance by Front-Running <code>liquidateCreditAccount()</code> with Ownership Transfer		
Asset	contracts/credit/CreditFacade.sol		
Status	Open		
Rating	Severity: High	Impact: High	Likelihood: Medium

Description

Due to liquidations being performed on the borrower's address and not the `CreditAccount`, users can feasibly avoid liquidation by front-running calls to `liquidateCreditAccount()` and transferring `CreditAccount` ownership to a different address.

Considering that Gearbox intends to deploy their contracts on low-cost blockchains, it is entirely possible for users to sustain such an attack until the borrower's collateral does not sufficiently cover the loss. As a result, liquidity providers will have to cover the shortage in collateral when a liquidator closes a uncollateralised credit account.

Recommendations

Ensure that liquidations operate on the address of the credit account and not the borrower. Changes in credit account ownership should not affect the overall functionality of the Gearbox protocol.

GRB-08	approve() Will Revert on Any Credit Account		
Asset	contracts/credit/CreditFacade.sol		
Status	Resolved: See Resolution		
Rating	Severity: High	Impact: Medium	Likelihood: High

Description

`CreditFacade.approve()` passes the `creditAccount` variable as the `borrower` parameter of `CreditManager.approveCreditAccount()`. This causes calls to `getCreditAccountOrRevert(borrower)` to always revert because the `creditAccount` does not exist.

Recommendations

Parse `msg.sender` as the `borrower` parameter in the `CreditManager.approveCreditAccount()` function call.

Resolution

The development team has fixed this in commit [5e35d31](#).

GRB-09	Tokens Passed in Incorrect Order when Calling <code>fastCollateralCheck()</code>		
Asset	contracts/adapters/convex/ConvexV1_BaseRewardPool.sol		
Status	Open		
Rating	Severity: Medium	Impact: Medium	Likelihood: Medium

Description

When calling the `fastCollateralCheck()` function to perform account's health check, tokens are passed in incorrect order not matching their corresponding balances, resulting in unexpected results when calculating `CreditAccount`'s health.

The issue persists in `_withdraw()` and `_withdrawAndUnwrap()` functions of `ConvexV1_BaseRewardPool.sol`.

Additionally, an incorrect token is referenced in `fastCollateralCheck()` of the `_withdrawAndUnwrap()` function.

Affected code in `_withdraw()` function:

```
uint256 balanceInBefore = IERC20(stakedPhantomToken).balanceOf(creditAccount);
uint256 balanceOutBefore = IERC20(cvxLPtoken).balanceOf(creditAccount);

// ...

if (msg.sender != creditFacade) {
    creditManager.fastCollateralCheck(
        creditAccount,
        cvxLPtoken,           // note, 'balanceInBefore' above is calculated on 'stakedPhantomToken', not 'cvxLPtoken'
        stakedPhantomToken,
        balanceInBefore,
        balanceOutBefore
    );
}
```

Affected code in `_withdrawAndUnwrap()` function:

```
uint256 balanceInBefore = IERC20(stakedPhantomToken).balanceOf(creditAccount);
uint256 balanceOutBefore = IERC20(curveLPtoken).balanceOf(creditAccount); // note, 'curveLPtoken' referenced

// ...

if (msg.sender != creditFacade) {
    creditManager.fastCollateralCheck(
        creditAccount,
        cvxLPtoken,           // note, 'cvxLPtoken' referenced, when balances are calculated on 'curveLPtoken'. Also incorrect
        ↪ ordering.
        stakedPhantomToken,
        balanceInBefore,
        balanceOutBefore
    );
}
```

Recommendations

Switch order of tokens passed in as parameters to `fastCollateralCheck()` function and ensure their order matches the order of their corresponding balances which are passed in as parameters to the same function.

Correct token references in `fastCollateralCheck()` to ensure they match their corresponding balances.

GRB-10	Incorrect Construction of stakedPhantomToken		
Asset	contracts/adapters/convex/ConvexV1_BaseRewardPool.sol		
Status	Open		
Rating	Severity: Medium	Impact: Medium	Likelihood: Medium

Description

In the constructor code of `ConvexV1BaseRewardPoolAdapter`, the `stakedPhantomToken` is created with the pool's staking token passed in as first parameter, instead of the pool address itself.

As such, phantom token will not return correct balances, which will result in unexpected behaviour in other functions.

Affected code:

```
stakedPhantomToken = address(
  new ConvexStakedPositionToken(
    address(IBaseRewardPool(_baseRewardPool).stakingToken()), // note, 'stakingToken()' address referenced, instead of pool
    ↪ address
    cvxLPtoken
  )
);
```

Note constructor declaration of `ConvexStakedPositionToken` - `constructor(address _pool, address _lptoken)`.

Recommendations

Modify call constructing `stakedPhantomToken` from `address(IBaseRewardPool(_baseRewardPool).stakingToken())` to `address(IBaseRewardPool(_baseRewardPool))`.

GRB-11	Premature Self-Destruct of PoolFactory		
Asset	contracts/factories/PoolFactory.sol		
Status	Open		
Rating	Severity: Medium	Impact: High	Likelihood: Low

Description

`PoolFactory` may be self-destructed while being sole owner of `ACL` contract.

During pool deployment, the ownership of `ACL` contract is transferred to `PoolFactory` to preform its configuration.

After `PoolFactory.configure()` is called, the ownership is transferred back to the configurator. Additional `PoolFactory.getRootBack()` function is also provided to recover ownership in the case of configuration failure.

The function `PoolFactory.destroy()` self destructs the `PoolFactory` contract and there are no check to prevent this function from being called while `PoolFactory` is the owner of `ACL`. If such event occurs, nobody will have ownership of `ACL`, which will break many Gearbox functions.

Recommendations

Implement additional checks to ensure that `ACL` ownership has been returned to the configurator before selfdestructing `PoolFactory`.

GRB-12	Incorrect Token Amounts Used in add_liquidity()		
Asset	contracts/adapters/curve/CurveV1_stETHGateway.sol		
Status	Open		
Rating	Severity: Medium	Impact: Medium	Likelihood: Medium

Description

Incorrect amount of token1 is used to transfer funds to the CurveV1StETHPoolGateway, resulting in unexpected behaviour.

add_liquidity() function on L108 incorrectly references amount of token1 to transfer to the gateway for further processing. This will result in incorrect amount transferred out of the borrower's address and may also cause reverts due to insufficient balance or exceeding approved transfer amount.

Affected code:

```
function add_liquidity(
    uint256[N_COINS] memory amounts,
    uint256 min_mint_amount
) external {
    if (amounts[0] > 0) {
        IERC20(token0).safeTransferFrom(
            msg.sender,
            address(this),
            amounts[0]
        );
        IWETH(token0).withdraw(amounts[0]);
    }

    if (amounts[1] > 0) {
        IERC20(token1).safeTransferFrom(
            msg.sender,
            address(this),
            amounts[0] // note, 'amounts[0]' is referenced, instead of 'amounts[1]'
        );
    }
}
```

Recommendations

Change token1 amount on L108 of add_liquidity() function from amounts[0] to amounts[1].

GRB-13	Incorrect Account Address Results in Missed Rewards		
Asset	contracts/adapters/convex/ConvexV1_BaseRewardPool.sol		
Status	Open		
Rating	Severity: Medium	Impact: Medium	Likelihood: Medium

Description

Due to missing conversion of address passed in to `getReward(address _account, bool)` function from borrower's address to corresponding `CreditAccount`, users will miss accumulated rewards.

Address passed in to the function `getReward(address _account, bool)` is simply passed straight through to `creditManager.executeOrder()` without first being converted to corresponding Credit Account's address. As a result, further call to Convex's `BaseRewardPool` will fail, as account of this address does not exist.

Additionally, the `creditManager.executeOrder()` function is called passing in `msg.sender` as a borrower, instead of `_account`, resulting in further calls being executed from `msg.sender`'s credit account.

```
function getReward(address _account, bool)
    external
    override
    returns (bool)
{
    address creditAccount = creditManager.getCreditAccountOrRevert(
        _account
    );

    creditManager.executeOrder(
        msg.sender, // note, this will result in request executed from 'msg.sender' Credit Account, not the provided '_account'
        address(baseRewardPool),
        msg.data // note, this contains '_account' address, not 'creditAccount' address, as such the Convex getReward() call
                // will fail as no such account exist
    );
}
```

Recommendations

Rewrite calldata passed in to the `getReward(address _account, bool)` function to use corresponding Credit Account's address before using it further in `creditManager.executeOrder()`.

Modify first parameter passed in `creditManager.executeOrder()` to match intended borrower.

GRB-14	Flashloan Protection Bypass Through Debt Increase and Account Closure Within The Same Block		
Asset	contracts/credit/CreditFacade.sol		
Status	Open		
Rating	Severity: Medium	Impact: Medium	Likelihood: Medium

Description

It is possible to bypass the [flashloan attack protection](#).

Whilst the existing flashloan attack protection mechanism prevents users from opening and closing credit accounts within the same transaction (block), this check does not prevent users from increasing their debt position beyond the limits of their collateralization ratio (up to `maxBorrowedAmount`) and closing the account within the same transaction. This acts as a fee-less flashloan for borrowers.

Specifically, there are two ways to exploit this vulnerability:

- by calling functions of adding collateral, increasing debt and closing credit account sequentially, in the same block (e.g. when called as a single function from an external contract)
- by exploiting lack of collateral checks during the `_multicall()` operations in `CreditManger.closeCreditAccount()`, as the pool is assumed to be repaid, and non-underlying assets are assumed to be transferred, by the end of the transaction.

Recommendations

Implement checks to ensure `increaseDebt()` and `closeCreditAccount()` are not executed in the same block.

Alter the logic of `CreditFacade._multicall()` to limit its capabilities during account closures. Note, this specific case has already been addressed in commit [bdbabc](#).

GRB-15	Chainlink Oracle Data Feeds Lack Validation		
Asset	contracts/oracles/PriceOracle.sol and contracts/oracles/yearn/YearnPriceFeed.sol		
Status	Open		
Rating	Severity: Medium	Impact: High	Likelihood: Low

Description

Chainlink oracle data feeds lack validation to ensure that the data is fresh and from a complete round. Oracle malfunctions may lead to large scale liquidation events or alternatively it may put the protocol at risk of insolvency.

Recommendations

Validate the output of Chainlink's `latestRoundData()` function to match the following code snippet:

```
(
uint80 roundID,
int256 price,
,
uint256 updateTime,
uint80 answeredInRound
) = AggregatorV3Interface(priceFeeds[token]).latestRoundData();
require(
    answeredInRound >= roundID,
    "Chainlink Price Stale"
);
require(price > 0, "Chainlink Malfunction");
require(updateTime != 0, "Incomplete round");
```

It is important that these checks are added to all cases where `latestRoundData()` is used.

GRB-16	Curve Adapters May Fail to Enable Tokens if a Zeroised <code>min_amounts</code> Array is Provided		
Asset	<code>contracts/adapters/curve/*</code>		
Status	Open		
Rating	Severity: Low	Impact: Medium	Likelihood: Low

Description

Gearbox's Curve adapters may fail to enable tokens, resulting in inaccurate `CreditAccount` health check calculations.

Gearbox's Curve adapters will check and enable tokens if the credit account receives an amount of tokens greater than zero when removing liquidity. The check is performed in the `_remove_liquidity_int()` function, however, because the check is done on a potentially zeroised `min_amounts` array, it is possible that the credit account will fail to consider tokens removed from the liquidity pool.

As a result, this may lead to unexpected liquidations as the health of the user's credit account deteriorates due to this edge case.

Recommendations

Enforce that the `min_amounts` array contains no zero values. Alternatively, consider checking the before and after balance of each token is positive before calling `checkAndEnableToken()`.

GRB-17	Credit Accounts Can Pass a Full Collateral Check and Also be Liquidatable		
Asset	contracts/credit/CreditManager.sol and contracts/credit/CreditFacade.sol		
Status	Open		
Rating	Severity: Low	Impact: Medium	Likelihood: Low

Description

A Credit Account may be qualified as applicable for liquidation and pass collateral health check at the same time.

When a Credit Account performs an operation on its assets, it will then perform a collateral check to ensure that the operation has not caused the health factor of the Credit Account to drop below 1.

Due to the method of calculating the Credit Account health factor differing between `CreditManager.fullCollateralCheck()` and `CreditFacade.liquidateCreditAccount()` this can lead to an account passing the `CreditManager.fullCollateralCheck()` and also being qualified to be liquidated by `CreditFacade.liquidateCreditAccount()`.

This is demonstrated in the unit test `test_exploit_liquidatable_and_fullCollateralPass()` in the test file for `CreditManager.sol`. The difference is that one function calculates the health factor in terms of the underlying asset and the other calculates it in terms of dollars leads to a truncation issue with price feeds with accuracy below 18d.p. This truncation then leads to different quantities being evaluated on line [639] of `CreditManager.sol` and line [288] of `CreditFacade.sol`.

Recommendations

Change the calculation used for an account health factor to be consistent throughout different contracts.

When possible make use of unit testing and fuzzing to detect when edge-case scenarios give different outcomes.

GRB-18	Calls to <code>calcBorrowRate()</code> Can Fail if Variable is Set Incorrectly		
Asset	<code>contracts/pool/LinearInterestRateModel.sol</code>		
Status	Open		
Rating	Severity: Low	Impact: Low	Likelihood: Low

Description

Setting `U_optimal = PERCENTAGE_FACTOR` can cause unexpected reverts due to division by zero.

On line [46] of `LinearInterestRateModel.sol` the check `U_optimal <= PERCENTAGE_FACTOR` is made, however setting `U_optimal = PERCENTAGE_FACTOR` can later cause problems as this results in `_U_Optimal_inverted_WAD = 0` on line [55].

Subsequently, division on line [102] will then always revert due to division by zero, meaning calls to `calcBorrowRate()` will always revert.

Recommendations

Change line [46] to be a strict inequality `U_optimal < PERCENTAGE_FACTOR` in order to prevent this issue occurring.

GRB-19	Credit Accounts May be Returned with Residual Assets	
Asset	contracts/credit/CreditFacade.sol and contracts/core/AccountFactory.sol	
Status	Open	
Rating	Informational	

Description

If a `creditAccount` is closed (or liquidated) with `sendAllAssets` parameter as false, the residual (non-underlying) assets will remain in the `creditAccount` if they are not transferred or converted to underlying via `_multicall()`.

These assets will be inherited by the next borrower assigned to this `creditAccount`.

Recommendations

Provide documentation so that users are aware of these implications and can take steps towards avoiding them.

GRB-20	Incorrect creditConfigurator Upgrades Will Lock Configuration	
Asset	contracts/credit/CreditConfigurator.sol and contracts/tokens/GearToken.sol	
Status	Open	
Rating	Informational	

Description

If `CreditConfigurator.upgradeConfigurator()` is called by the configurator (owner of ACL contract) with an incorrect contract address, then `creditConfigurator` will be locked at this address and several parameters of `CreditManager` and `CreditFacade` will be locked forever.

Recommendations

Implement a two-step upgrade process, whereby the configurator sets the new `creditConfigurator` address and then the new `creditConfigurator` must claim the role.

Note: This vulnerability is also present in GearToken.sol

GRB-21	Miscellaneous Gearbox General Comments	
Asset	contracts/*	
Status	Open	
Rating	Informational	

Description

This section details miscellaneous findings in the `contracts` repository discovered by the testing team that do not have direct security implications:

1. `core/DataCompressor.sol`

1a) Loop Limit Called Each Cycle

To save gas these loop limits on line [79] and line [94] should be stored in a local variable rather than queried each cycle.

1b) Loop Increment Called in Checked Maths

To save gas this loop incrementing on line [80] and line [95] can be placed in an unchecked block at the end of the loop as it is already restricted by the loop termination condition so will not overflow.

1c) Stale Code

There is stale code in the following lines, this should be removed to avoid confusion: line [139], line [153] and line [172].

1d) Typos

line [68]: particluar, should be particular.

line [68]: account, should be accounts.

line [188]: bborrower, should be borrower.

line [217]: flg, should be flag.

line [270]: particulr, should be particular.

line [325]: non-standart, should be non-standard.

1e) Missing Inheritance

Consider having `DataCompressor.sol` inherit from its interface `IDataCompressor.sol` to ensure that it is implemented correctly.

1f) Misleading Modifier Naming

Modifiers `registeredCreditManagerOnly(address creditManager)` and

`registeredPoolOnly(address pool)` are intended to check that the target of the call is a credit manager or a pool. They do not check the caller of the function. Consider renaming to `targetIsCreditManager(address target)` to clarify intent.

1g) Unused Local Variables

The return value `ICreditFacade creditFacade` assigned to a local variable on line [125], line [227], line [360], and line [404] is not used and can be removed. The call assigning `uint256 allowedTokenCount` on line [151] can be removed.

2. `core/ACL.sol`

2a) Missing Inheritance

Consider having `ACL.sol` inherit from its interface `IACL.sol` to ensure that it is implemented correctly.

3. `credit/CreditManager.sol`

3a) Imports Hardhat Console

On line [25] there is an import that only functions when not on the mainnet and so should be removed.

3b) Confusing Comment

On line [38] the `Account Factory` is referred to as the account manager which may get confusing as the `Credit Manager` is the manager for credit accounts. The comment should be edited to make the differing roles clearer.

3c) Typo in Variable Name

On line [84] the variable `forbidenTokenMask` is introduced, it should be named `forbiddenTokenMask` here and at other places of use.

3d) Confusing Comment

On line [89] the comment suggests we record which block we last used the `fast check` mechanism when in fact the mapping records how often we have used the `fast check` mechanism in the same block.

3e) Inconsistent Naming Scheme

On line [617] refers to a variable `total` where in other contracts this calculation is referred to as `twv` short for `Threshold Weighted Value` while `total` is reserved for calculations of `Total value` as described in the `whitepaper`.

3f) Gas Optimization

On line [727] and line [783] `tokenMask > 0` can be replaced with `tokenMask != 0` which is 3 gas cheaper and acts the same when acting on unsigned integers.

The function `upgradeContracts` can be separated to upgrade `creditFacade` or `priceOracle` individually.

3g) Operation Order Unclear

On line [727] and line [783] multiple operations are carried out on the same line, use brackets to indicate the intended order of actions to improve readability.

3h) Missing Zero Address Checks

The function `upgradeContracts` prevent `creditFacade` or `priceOracle` from being set to the zero address. If this happens, important Gearbox functions will break. The mistake can be recovered by calling `upgradeContracts` again (wasting gas), but implementing zero address checks would be appropriate.

3i) Typos

line [65]: `Miltiplier`, should be `Multiplier`.

line [71]: `Adress`, should be `Address`.

line [167]: `transffered`, should be `transferred`.

line [227]: `liqution`, should be `liquidation`.

line [279]: `addrss`, should be `address`.

line [280]: `it it`, should be `if it`.

line [345]: `cunulativeIndex`, should be `cumulativeIndex`.

line [347]: `decrecase`, should be `decrease`.

line [348]: `particall`, should be `partial`.

line [349]: `cumulativeIndex now`, should be `cumulativeIndexNow`.

line [353]: `fto`, should be `to`.

line [805]: `reverts of borrower has no one`, should be `reverts if borrower does not have one`.

line [823]: `Foloowing`, should be `Following`

3j) Public Function Could Be External

The public function `fullCollateralCheck()` can be declared as external.

4. `core/WETHGateway.sol`

4a) Typos

line [117]: `has`, should be `have`.

4b) Misleading Function Name

The function `_checkAllowance()` has side effects. It both checks the allowance and approves the maximum amount. Consider renaming the function to `_checkAndApproveAllowance()` to clarify the intent of the function.

4c) Misleading Modifier Name

The modifier `creditManagerOnly(address creditManager)` is intended to check that the caller is a `creditManager`. However, it expects that `msg.sender` be passed in as a parameter. Consider removing the parameter and instead check the caller directly to clarify usage.

4d) Unused Modifier

The modifier `wethCreditManagerOnly(address creditManager)` is not used and can be removed.

5. **credit/CreditAccount.sol**5a) Inconsistent Use of `approve()` and `safeApprove()`

On line [95] and line [109] we have an inconsistent use of ERC20's function `approve()` and the Open Zeppelin wrapper `safeApprove()`

5b) Typos

line [54]: cause, should be because.

line [59]: Connects credit account to credit account address., should be Connects credit account to credit manager address..

5c) Misleading Access Control

The functions `connectTo()` and `cancelAllowance()` do not have any modifiers and may be assumed to be callable by anyone. However, a require statement in the function restricts access to calls from `factory`. Consider implementing a `factoryOnly` modifier to clarify the access control.

6. **credit/CreditConfigurator.sol**

6a) Typo in Variable Name

On line [216] the variable `forbidenTokenMask` is introduced, it should be named `forbiddenTokenMask` here and at other places of use.

6b) Typos

line [70]: condigures, should be configures.

line [134]: revers, should be reverts.

line [159], line [219], line [246]: cause, should be because.

line [244]: undelrying, should be underlying.

line [445] undelrying should be underlying.

line [491]: This internal function is check the need of additional sanity checks, should be This internal function conducts additional sanity checks

6c) Conflict Between Documentation and Implementation

Comments on line [63] through line [73] describe the correct deployment flow for `CreditManager`, `CreditFacade`, and `CreditConfigurator` contracts. However, these steps occur out of order in the factory contracts. Step 3 does not occur until Step 6, in the constructor of `CreditConfigurator`.

7. **pool/LinearInterestRateModel.sol**

7a) Inconsistent Notation

On line [20], line [36] until line [39] and line [107] a mix of commas and periods are used to denote a thousands separator. Both should be avoided as depending on which country the reader is from they can be interpreted as decimal places. I.e. 10.000 may be mistaken for 10.000% If writing clarity is needed prefer 10_000 or 10 000.

7b) Mismatched Naming Scheme

On line [79] the variable name `U_WAD` naming style may lead to readers assuming it is a constant.

7c) Constant Interest Model Parameters

It is not possible to update the interest model parameters and so if an asset is being over/underutilized this cannot be fixed by governance.

7d) Suitable Future Interest Models

The current interest model is a piecewise continuous function, it is important that if a different interest model is adopted it must also be a continuous function. Otherwise it may be possible to disproportionately affect the paid interest rate by donating a small amount of the underlying token to the pool.

7e) Typos

line [50]: percetns, should be percents.

8. **credit/CreditFacade.sol**

8a) Identical Function Names

Both `CreditFacade.sol` and `CreditManager.sol` contain a function called `transferAccountOwnership()` one of these should be changed to avoid confusion.

8b) Type In Variable Name

The `twv` return variable assigned on line [283] should be called `twv` to match usage in other places.

8c) Typos

line [403]: Requires, should be Required.

line [428]: cause account trasfership were trasffered here, should be because account ownership was transferred here.

line [436]: cause address(this) has no sense, should be because address(this) makes no sense.

line [477]: powerfull, should be powerful.

line [532]: who unexpect this, should be who does not expect this.

line [548]: borbidden, should be forbidden.

8d) Public Functions Could Be External

The public functions `calcCreditAccountHealthFactor()` and `hasOpenedCreditAccount()` could be declared external.

8e) Unused Local Variables

The call assigning `address creditAccount` on line [522] can be removed.

9. **core/AccountFactory.sol**

9a) Typos

line [157]: if no one in stock, should be if there are none in stock.

line [323]: accoutn should be account

line [345]: desinged should be designed

10. **oracles/PriceOracle.sol**

10a) Inaccurate Comment

line [56] and line [147] suggest that the Chainlink price feed should be a `TOKENETH` pair however discussions with the Gearbox team suggested `TOKENUSD` price feeds were preferred due to better update characteristics. This is important to document clearly as `ETH` price feeds use 18d.p. while `USD` price feeds use only 8d.p.

10b) Gas Optimizations

On line [152] we load `priceFeeds[token]` from storage then again on line [163], the first instance should be stored in a local variable then accessed via that on line [163] to save gas.

On line [161] we create a local variable `timeStamp` however this is never used.

10c) Public Function Could Be External

The public function `convert()` could be declared external.

11. **adapters/yearn/YearnV2.sol**

11a) Magic Constants

On line [105] and line [187] the function selectors are hardcoded without an explanation of what they are. These should be turned into constant variables with suitable names and explanations of how they are derived.

11b) Conflict Between Documentation and Implementation

Comments on line [161] and line [162] suggest that the `uint256 maxLoss` parameter of `withdraw(uint256,address,uint256)` function should specify the maximum acceptable loss that can be sustained on withdrawal. However, the function does not implement such logic.

12. **pool/PoolService.sol**

12a) Public Functions Could Be External

The public functions `updateInterestRateModel()` and `setWithdrawFee()` could be declared external.

12b) Typos

line [143]: `amoung` should be `amount`
 line [309]: `corretly` should be `correctly`
 line [317]: `profitabe` should be `profitable`
 line [458]: `undelying` should be `underlying`
 line [468]: `Credif` should be `Credit`
 line [469], line [490], line [491]: `credif` should be `credit`
 line [490]: `particulat` should be `particular`

13. **adapters/convex/ConvexV1_Booster.sol**

13a) Stale Code

`_amount` input on line [136] is never used.

14. **adapters/convex/ConvexV1_BaseRewardPool.sol**

14a) Constant Return Statements

Several functions in this contract return bools however they always return true. This affects functions `_stake()` on line [144], `_withdraw()` on line [196], `_withdrawAndUnwrap()` on line [243], `getReward()` on line [282] and `getReward()` on line [302]. The return statements should either be removed or have multiple outcomes.

15. **adapters/curve/CurveV1_stETH.sol**

15a) Typo

line [50]: `Deisgned`, should be `Designed`.

16. **adapters/curve/CurveV1_stETHGateway.sol**

16a) Lack of ReentrancyGuard and no `nonReentrant` modifier on `exchange()`, `add_liquidity()` and `remove_liquidity()` functions

17. **adapters/lido/LidoV1.sol**

17a) Incorrect global variable value

line [38]: `_gearboxAdapterType`, is incorrectly set to `AdapterType.CONVEX_V1_CLAIM_ZAP`.

17b) No `nonReentrant` modifier on `submit()` function

18. **adapters/lido/LidoV1_WETHGateway.sol**

18a) Lack of ReentrancyGuard and no `nonReentrant` modifier on `submit()` function

19. oracles/curve/CurveLP2PriceFeed.sol**19a) Magic Constant**

On line [89] there is a magic constant `10**18` this should be replaced with a named constant to improve readability.

20. oracles/yearn/YearnPriceFeed.sol**20a) Gas Optimization**

On line [117] replace `_lowerBound > 0` with `_lowerBound != 0` as this is 3 gas cheaper and acts the same when acting on unsigned integers.

21. libraries/Errors.sol**21a) Typo in Error Message**

line [48]: `CM_CAN_LIQUIDATE`, should be `CM_CANNOT_LIQUIDATE`

22. tokens/GearToken.sol**22a) Typo**

line [184]: `to spends`, should be `to spend`

22b) Redundant Check

line [430] of `_transferTokens()` prevents the zero address from sending tokens. However, it is impossible for the zero address to hold tokens. Therefore, this check can be removed.

23. factories/PoolFactory.sol**23a) Typo**

line [104]: `destroy`, should be `destroy`

Recommendations

Ensure that the comments are understood and acknowledged, and consider implementing the suggestions above.

Appendix A Test Suite

A non-exhaustive list of tests were constructed to aid this security review and are provided alongside this document. The `brownie` framework was used to perform these tests and the output is given below.

test_constructor	PASSED	[0%]
test_stakeAll	XFAIL	[1%]
test_stake	XFAIL	[1%]
test_withdraw_claimFalse	XFAIL	[2%]
test_withdraw_claimTrue	XFAIL	[2%]
test_withdrawAll_claimFalse	XFAIL	[3%]
test_withdrawAll_claimTrue	XFAIL	[3%]
test_getReward	XFAIL	[4%]
test_getReward_Account_ClaimExtrasFalse	XFAIL	[4%]
test_withdrawAndUnwrap_claimFalse	XFAIL	[5%]
test_withdrawAndUnwrap_claimTrue	XFAIL	[5%]
test_withdrawAllAndUnwrap_claimFalse	XFAIL	[6%]
test_withdrawAllAndUnwrap_claimTrue	XFAIL	[6%]
test_constructor	PASSED	[7%]
test_updateStakedPhantomTokensMap	PASSED	[7%]
test_deposit_stakeTrue	PASSED	[8%]
test_deposit_stakeFalse	PASSED	[8%]
test_depositAll_stakeTrue	PASSED	[9%]
test_depositAll_stakeFalse	PASSED	[9%]
test_withdraw	PASSED	[10%]
test_withdrawAll	PASSED	[10%]
test_constructor	PASSED	[11%]
test_claimRewards	XFAIL	[11%]
test_constructor	XFAIL	[12%]
test_forbiddenFunctions	PASSED	[13%]
test_balanceOf	XFAIL	[13%]
test_constructor	PASSED	[14%]
test_add_liquidity	PASSED	[14%]
test_remove_liquidity	PASSED	[15%]
test_remove_all_liquidity	PASSED	[15%]
test_constructor	PASSED	[16%]
test_add_liquidity	PASSED	[16%]
test_remove_liquidity	PASSED	[17%]
test_remove_all_liquidity	PASSED	[17%]
test_constructor	PASSED	[18%]
test_add_liquidity	PASSED	[18%]
test_remove_liquidity	PASSED	[19%]
test_remove_all_liquidity	PASSED	[19%]
test_constructor	PASSED	[20%]
test_exchange_underlying	PASSED	[20%]
test_coins	PASSED	[21%]
test_exchange_large_amount	PASSED	[21%]
test_exchange_small_amount	XFAIL	[22%]
test_exchangeAll	PASSED	[23%]
test_get_dy_underlying	PASSED	[23%]
test_get_dy	PASSED	[24%]
test_get_virtual_price	PASSED	[24%]
test_constructor	PASSED	[25%]
test_add_liquidity	PASSED	[25%]
test_remove_liquidity	PASSED	[26%]
test_remove_all_liquidity	PASSED	[26%]
test_constructor	PASSED	[27%]
test_exchange	PASSED	[27%]
test_add_liquidity	XFAIL	[28%]
test_remove_liquidity	XFAIL	[28%]
test_get_dy	PASSED	[29%]
test_get_virtual_price	PASSED	[29%]
test_constructor	PASSED	[30%]
test_submit	XFAIL	[30%]
test_constructor	PASSED	[31%]
test_swapTokensForExactTokens	PASSED	[31%]
test_swapExactTokensForTokens	PASSED	[32%]
test_read	PASSED	[32%]
test_constructor	PASSED	[33%]

test_extractTokens	XFAIL	[33%]
test_exactInputSingle	PASSED	[34%]
test_exactAllInputSingle	PASSED	[35%]
test_exactInput	PASSED	[35%]
test_exactOutputSingle	PASSED	[36%]
test_exactOutput	PASSED	[36%]
test_constructor	PASSED	[37%]
test_deposit	PASSED	[37%]
test_deposit_uint256	PASSED	[38%]
test_deposit_uint256_address	PASSED	[38%]
test_withdraw	PASSED	[39%]
test_withdraw_uint256	PASSED	[39%]
test_withdraw_uint256_address	PASSED	[40%]
test_version	PASSED	[40%]
test_add_removePausableAdmin	PASSED	[41%]
test_add_removeUnpausableAdmin	PASSED	[41%]
test_isConfigurator	PASSED	[42%]
test_renounceOwnership	PASSED	[42%]
test_constructor	PASSED	[43%]
test_creditAccount	PASSED	[43%]
test_countCreditAccountsInStock[10]	SKIPPED	[44%]
test_countCreditAccountsInStock[100]	SKIPPED	[45%]
test_countCreditAccountsInStock[1000]	SKIPPED	[45%]
test_countCreditAccountsInStock[10000]	SKIPPED	[46%]
test_takeOut	PASSED	[46%]
test_mine	PASSED	[47%]
test_mine_duplicate	PASSED	[47%]
test_getter	PASSED	[48%]
test_version	PASSED	[48%]
test_addPool	PASSED	[49%]
test_addPool_multi	PASSED	[49%]
test_addCreditManager	PASSED	[50%]
test_addCreditManager_multi	PASSED	[50%]
test_pause_unpause	PASSED	[51%]
test_constructor	PASSED	[51%]
test_add_remove_LiquidityETH	PASSED	[52%]
test_unwrapWETH	PASSED	[52%]
test_receive	PASSED	[53%]
test_initialize	PASSED	[53%]
test_connectTo	PASSED	[54%]
test_updateParameters	PASSED	[54%]
test_approveToken	PASSED	[55%]
test_cancelAllowance	PASSED	[56%]
test_safeTransfer	PASSED	[56%]
test_constructor_check	PASSED	[57%]
test_addTokenToAllowedList	PASSED	[57%]
test_setLiquidationThreshold	PASSED	[58%]
test_allow_forbid_Token	PASSED	[58%]
test_allow_forbid_Contract	PASSED	[59%]
test_setLimits	PASSED	[59%]
test_setFastCheckParameters	PASSED	[60%]
test_setFees	PASSED	[60%]
test_upgradePriceOracle	PASSED	[61%]
test_upgradeCreditFacade	PASSED	[61%]
test_upgradeConfigurator	PASSED	[62%]
test_constructor	PASSED	[62%]
test_openCreditAccount_WETH	PASSED	[63%]
test_openCreditAccount	PASSED	[63%]
test_close_CreditAccount	PASSED	[64%]
test_openCreditAccountMulticall	PASSED	[64%]
test_openCreditAccountMulticall_increaseDebt	PASSED	[65%]
test_openCreditAccountMulticall_decreaseDebt	PASSED	[65%]
test_liquidateCreditAccount	PASSED	[66%]
test_approve	PASSED	[67%]
test_approve_transfer_AccountOwnership	PASSED	[67%]
test_setContractToAdapter	PASSED	[68%]
test_liquidateAccount_poolFundsTheft	PASSED	[68%]
test_liquidateAccount_contractAddress	PASSED	[69%]
test_flashloanProtectionBypass	XFAIL	[69%]
test_openCreditFacade_DoS	PASSED	[70%]

test_multicall_addCollateral_noAccount	PASSED	[70%]
test_closeCreditAccount_increaseDebt_noCollateralCheck	PASSED	[71%]
test_constructor	PASSED	[71%]
test_openCreditAccount	PASSED	[72%]
test_manageDebt_increase	PASSED	[72%]
test_manageDebt_decrease	PASSED	[73%]
test_transferAccountOwnership	PASSED	[73%]
test_approveCreditAccount	PASSED	[74%]
test_checkAndEnableToken	PASSED	[74%]
test_fastCollateralCheck	PASSED	[75%]
test_fullCollateralCheck	PASSED	[75%]
test_setParams	PASSED	[76%]
test_setLiquidationThreshold	PASSED	[76%]
test_setForbidMask	PASSED	[77%]
test_changeContractAllowance	PASSED	[78%]
test_upgradeContracts	PASSED	[78%]
test_setConfigurator	PASSED	[79%]
test_executeOrder	PASSED	[79%]
test_exploit_liquidatable_and_fullCollateralPass	PASSED	[80%]
test_constructor	PASSED	[80%]
test_constructor	PASSED	[81%]
test_getRootBack	PASSED	[81%]
test_destroy	PASSED	[82%]
test_constructor	PASSED	[82%]
test_getRoundData	PASSED	[83%]
test_latestRoundData	PASSED	[83%]
test_constructor	PASSED	[84%]
test_addPriceFeed	PASSED	[84%]
test_converts	PASSED	[85%]
test_constructor	PASSED	[85%]
test_getRoundData	PASSED	[86%]
test_latestRoundData	PASSED	[86%]
test_fastPrice	PASSED	[87%]
test_constructor	PASSED	[87%]
test_getModelParameters	PASSED	[88%]
test_constructor	PASSED	[89%]
test_add_remove_Liquidity	PASSED	[89%]
test_lend_repay_CreditAccount	PASSED	[90%]
test_connect_forbid_CreditManager	PASSED	[90%]
test_updateInterestRateModel	PASSED	[91%]
test_setExpectedLiquidityLimit	PASSED	[91%]
test_setWithdrawFee	PASSED	[92%]
test_constructor	PASSED	[92%]
test_bestUniPath	PASSED	[93%]
test_convertPathToPathV3	PASSED	[93%]
test_getPrices	PASSED	[94%]
test_constructor	PASSED	[94%]
test_transferOwnership	PASSED	[95%]
test_setMiner	PASSED	[95%]
test_allowTransfers	PASSED	[96%]
test_approve	PASSED	[96%]
test_permit	PASSED	[97%]
test_transfer	PASSED	[97%]
test_transferTokens	PASSED	[98%]
test_delegate	PASSED	[98%]
test_transferFrom	PASSED	[99%]
test_delegateBySig	PASSED	[100%]

Appendix B Vulnerability Severity Classification

This security review classifies vulnerabilities based on their potential impact and likelihood of occurrence. The total severity of a vulnerability is derived from these two metrics based on the following matrix.

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

Table 1: Severity Matrix - How the severity of a vulnerability is given based on the *impact* and the *likelihood* of a vulnerability.

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