AstraSec

Magpie

Security Audit Report

August 26, 2024

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1 | Introduction

1.1 About Magpie

The `Magpie DAO` is a suite of protocols that transcends conventional platforms with the goal of enhancing participation and user opportunities across `DeFi`. Integrated with an array of structures and solutions, `Magpie` adapts itself to different frameworks with the goal of achieving continuous growth while supporting the core functionalities of the decentralized finance ecosystem. As a `Mega DAO` composed by various `SubDAOs`, `Magpie` focuses on blackholing governance tokens, offering liquid restaking services for `Ethereum` and liquid staking for `Bitcoin`.

1.2 Audit Scope

	LINK	Base Commit	Final Commit
1	https://github.com/magpiexyz/magpie_contracts/tree/Launchpad	7aacd21	80463d7
2	https://github.com/magpiexyz/magpie_contracts/pull/168	fefcf60	be88d54
3	https://github.com/magpiexyz/magpie_contracts/pull/187	a337217	dc0d8ab
4	https://github.com/magpiexyz/magpie_contracts/pull/193	9d0b050	9107af0

1.3 Changelog

Version	Date
First Audit	December 11, 2023
Second Audit	February 7, 2024
Third Audit	July 15, 2024
Fourth Audit	August 26, 2024

2 | Overall Assessment

This report has been compiled to identify issues and vulnerabilities within the `Magpie` project. Throughout this audit, we identified several issues spanning various severity levels. By employing auxiliary tool techniques to supplement our thorough manual code review, we have discovered the following findings.

Severity	Count	Acknowledged	Won't Do	Addressed
Critical	-	-	-	-
High	2	-	-	2
Medium	2	1	-	1
Low	3	1	-	2
Informational	1	-	-	1
Undetermined	-	-	-	-

3 | Vulnerability Summary

3.1 Overview

Click on an issue to jump to it, or scroll down to see them all.

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I-1   Improved Gas Efficiency in ARBRewarder::_calculateAndSendARB()

3.2 Security Level Reference

In web3 smart contract audits, vulnerabilities are typically classified into different severity levels based on the potential impact they can have on the security and functionality of the contract. Here are the definitions for critical-severity, high-severity, medium-severity, and low-severity vulnerabilities:

Severity	Description
C-X (Critical)	A severe security flaw with immediate and significant negative consequences. It poses high risks, such as unauthorized access, financial losses, or complete disruption of functionality. Requires immediate attention and remediation.
H-X (High)	Significant security issues that can lead to substantial risks. Although not as severe as critical vulnerabilities, they can still result in unauthorized access, manipulation of contract state, or financial losses. Prompt remediation is necessary.
M-X (Medium)	Moderately impactful security weaknesses that require attention and remediation. They may lead to limited unauthorized access, minor financial losses, or potential disruptions to functionality.
L-X (Low)	Minor security issues with limited impact. While they may not pose significant risks, it is still recommended to address them to maintain a robust and secure smart contract.
I-X (Informational)	Warnings and things to keep in mind when operating the protocol. No immediate action required.
U-X (Undetermined)	Identified security flaw requiring further investigation. Severity and impact need to be determined. Additional assessment and analysis are necessary.

3.3 Vulnerability Details

[H-1] Revisited Implementation Logic in LaunchPadV2::buy()/cancelOrder()

Target	Category	IMPACT	LIKELIHOOD	STATUS
LaunchPadV2.sol	Business Logic	High	High	🔗Addressed

The `LaunchpadV2` contract provides a public `buy()` function that allows users to purchase project tokens. If the purchase is made during the public phase, users can also specify an input parameter `_maxAfterPrice` to ensure that the price fluctuation during the token purchase does not exceed the target price that is set by the user.

When reviewing the implementation of the `buy()` function, we notice that a user's targetPrice might be violated due to the dynamic nature of the `updatedPrice` during the function's execution. As more users make purchases, the `updatedPrice` increases. Although a user may set and meet a specific target price at the time of their purchase, if more users participate and make purchase, the `updatedPrice` might exceed the originally target price, leading to a violation of the user's intended purchase conditions. This can result in unexpected outcomes where the user ends up paying more than they initially intended.

LaunchPadV2::buy()

```
257     function buy(
258         uint256 _amount,
259         uint256 _maxAfterPrice
260     ) external whenNotPaused isSaleActive nonReentrant {
261         if (_amount < min_sale_token_amount) {
262             revert InvalidAmount();
263         }

265         (bool isPrivatePhase, ) = getCurrentPhaseInfo();

267         PhaseInfo storage phaseInfo = isPrivatePhase ? privatePhase :
                publicPhase;

269         totalRaised += _amount;
270         phaseInfo.saleTokenDeposits += _amount;
271         UserInfo storage user = userInfo[msg.sender];

273         if (isPrivatePhase) {
274             _checkValidCapAndUpdate(_amount);
275             user.privatePhaseDeposits += _amount;
276         } else {
277             user.publicPhaseDeposits += _amount;
278             _rebalanceAndUpdate(_maxAfterPrice, true);
```

```
279            }

281            IERC20(saleToken).safeTransferFrom(msg.sender, address(this), _amount);
282            emit AllocationPurchased(msg.sender, _amount);
283        }
```

Note similar issue also exists in the `cancelOrder()` function of the same contract.

Remediation   Remove the slippage protection from the `buy()`/`cancelOrder()` functions and set a cap on the amount of sale tokens raised during the public sale phase instead. Additionally, to prevent potential DoS attacks, it is recommended to charge a cancellation fee when users cancel their orders.

[H-2] Incorrect Price Calculation in _getRebalancedTokenPerSaleToken()

Target	Category	IMPACT	LIKELIHOOD	STATUS
LaunchPadV2.sol	Business Logic	High	High	🔗Addressed

The helper function `_getRebalancedTokenPerSaleToken()` in the `LaunchpadV2` contract is intended to calculate the rebalanced token price per sale token based on the total sale token deposits and a specified private round price. During our review of this function, we identify an issue where the calculation formula for `rebalancedTokenPerSaleToken` incorrectly handles the decimal scaling between `projectTokenDecimals` and `saleTokenDecimals` (lines 534-536). This discrepancy in scaling factors can lead to inaccurate price calculations, potentially resulting in incorrect token allocation or pricing during the sale. It could undermine the fairness and integrity of the token sale process.

<div align="center">

LaunchPadV2::_getRebalancedTokenPerSaleToken()

</div>

```
526        /// @dev Rebalance token ratio; initially matches private phase, adjusts
                with public deposits.
527        function _getRebalancedTokenPerSaleToken(
528            uint256 _saleTokenDeposits,
529            uint256 _privateRoundPrice
530        ) internal view returns (uint256) {
531            if (_saleTokenDeposits == 0) {
532                return _privateRoundPrice;
533            } else {
534                uint256 rebalancedTokenPerSaleToken = ((publicPhase.saleCap -
                        allocatedInPrivatePhase) *
535                    (10 ** projectTokenDecimals) *
536                    1 ether) / (_saleTokenDeposits * (10 ** saleTokenDecimals));
537                return
538                    rebalancedTokenPerSaleToken < _privateRoundPrice
```

```
539                     ? rebalancedTokenPerSaleToken
540                     : _privateRoundPrice;
541           }
542       }
```

Remediation   Correctly handles the decimal scaling between `projectTokenDecimals` and `saleTokenDecimals` for above mentioned function. An example revision is shown as follows:

<div align="center">

LaunchPadV2::_getRebalancedTokenPerSaleToken()

</div>

```
526       /// @dev Rebalance token ratio; initially matches private phase, adjusts
              with public deposits.
527       function _getRebalancedTokenPerSaleToken(
528           uint256 _saleTokenDeposits,
529           uint256 _privateRoundPrice
530       ) internal view returns (uint256) {
531           if (_saleTokenDeposits == 0) {
532               return _privateRoundPrice;
533           } else {
534               uint256 rebalancedTokenPerSaleToken = ((publicPhase.saleCap -
                      allocatedInPrivatePhase) *
535                   (10 ** saleTokenDecimals) *
536                   1 ether) / (_saleTokenDeposits * (10 ** projectTokenDecimals));
537               return
538                   rebalancedTokenPerSaleToken < _privateRoundPrice
539                       ? rebalancedTokenPerSaleToken
540                       : _privateRoundPrice;
541           }
542       }
```

[M-1] Revised Update of maxToDistribute in Launchpad::configLaunchpad()

Target	Category	IMPACT	LIKELIHOOD	STATUS
Launchpad.sol	Business Logics	Medium	Medium	Addressed

In the `Launchpad` contract, the project tokens are funded by the owner via the `configLaunchpad()` routine. The owner can adjust the maximum amount of project tokens to distribute before the start of the launchpad. Specially, if the owner increases the maximum amount (line 379), it needs to fund the increased amount of project tokens to the contract (line 380).

However, we notice it's possible that the owner may reduce the maximum amount, and there is a lack of refund for the decreased amount of project tokens back to the owner. Without the refund, the decreased amount of project tokens can't be withdrawn normally via the `withdrawUnsoldTokens()` routine, unless via emergency withdraw.

<div style="text-align: center;">**Launchpad::configLaunchpad()**</div>

```
374  maxRaiseAmount = _maxToRaise;
375  LOW_FDV_VESTING_PART = _lowFDVVestingPart;
376  HIGH_FDV_VESTING_PART = _highFDVVestingPart;
377  min_sale_token_amount = _minSaleTokenAmount;

379  if (_maxToDistribute > max_launch_tokens_to_distribute) {
380      IERC20(projectToken).safeTransferFrom(msg.sender,address(this),
             _maxToDistribute - max_launch_tokens_to_distribute);
381  }
382  max_launch_tokens_to_distribute = _maxToDistribute;
```

Remediation Promptly refund the decreased amount of project tokens back to the owner if it decreases the maximum amount of project tokens to distribute.

[M-2] Potential Risks Associated with Centralization

Target	Category	IMPACT	LIKELIHOOD	STATUS
Multiple Contracts	Security	Medium	Medium	Acknowledged

In the `Magpie Launchpad` protocol, the existence of a privileged owner account introduces centralization risks, as it holds significant control and authority over critical operations governing the protocol. In the following, we show the representative functions potentially affected by the privileges associated with the owner.

<div style="text-align: center;">**Launchpad::emergencyWithdrawFunds()**</div>

```
415      function emergencyWithdrawFunds(address token, uint256 amount) external
             whenPaused onlyOwner {
416          IERC20(token).safeTransfer(owner(), amount);

418          emit EmergencyWithdraw(token, amount);
419      }
```

<div style="text-align: center;">**LaunchPadV2::emergencyWithdrawFunds()**</div>

```
460      function emergencyWithdrawFunds(address _token, uint256 _amount) external
             whenPaused onlyOwner {
461          IERC20(_token).safeTransfer(owner(), _amount);
462          emit EmergencyWithdraw(_token, _amount);
463      }
```

Remediation   To mitigate the identified issue, it is recommended to designate a multi-sig account to undertake the role of the privileged `owner` account. Moreover, it is advisable to implement timelocks to govern all modifications to privileged operations.

Response By Team   This issue has been confirmed by the team. The multi-sig mechanism will be used to mitigate this issue.

[L-1] Revised Update of startTime in Launchpad::configLaunchpad()

Target	Category	IMPACT	LIKELIHOOD	STATUS
Launchpad.sol	Coding Practice	Medium	Low	Acknowledged

The `Launchpad` contract allows the owner to configure critical parameters for the launchpad, including the start time, project token, sale token, etc. Meanwhile, the owner can add new sale phases which shall be started later than the launchpad.

In particular, the owner can re-configure the launchpad before it is started as long as the new start time is sometime in future (line 357). However, we notice there is a lack of validation for the new start time to ensure it will be started before the first sale phase. As a result, if the launchpad is started after some sale phases, user can't participate in these overdue sale phases.

<div align="center">

Launchpad::configLaunchpad()

</div>

```
357  if (_startTime <= _currentBlockTimestamp()) revert InvalidTime();
358  if (_projectToken == address(0)) revert ZeroAddress();
359  if (_saleToken == address(0)) revert ZeroAddress();
360  if (_vestingContract == address(0)) revert ZeroAddress();
361  if (_lowFDVVestingPart >= DENOMINATOR) revert InvalidFDVPart();
362  if (_highFDVVestingPart >= DENOMINATOR) revert InvalidFDVPart();

364  uint8 projectTokenTokenDecimals = IERC20Metadata(_projectToken).decimals();
365  uint8 saleTokenDecimals = IERC20Metadata(_saleToken).decimals();

367  if (saleTokenDecimals > projectTokenTokenDecimals) revert
         TokenDecimalExceedsLimit();

369  projectToken = _projectToken;
370  saleToken = _saleToken;
371  vestingContract = ILaunchpadVesting(_vestingContract);
372  startTime = _startTime;
```

Remediation   Add a check for the new start time of the launchpad and ensure it will be started prior to the first sale phase (if any).

Response By Team   The issue has been confirmed by the team and they will examine the parameters.

[L-2] Improved Validation Checks in _checkValidCapAndUpdate()

Target	Category	IMPACT	LIKELIHOOD	STATUS
Launchpad.sol	Coding Practices	Low	Low	Addressed

The `Launchpad` contract provides an external `buy()` function for users to purchase a PROJECT Token allocation for the sale with a value of "amount" `saleToken`. This function requires that the provided amount of saleToken must not be less than `min_sale_token_amount`, but there is no corresponding check for the amount of PROJECT Token that the user can get in return.

To elaborate, we show below the implementation of the `_checkValidCapAndUpdate()` function. Our analysis shows that `_checkValidCapAndUpdate()` can be strengthened by further ensuring `require (amountOfTokensToBeAllocated > 0, 'Invalid allocation')` so that the buyer will not have potential asset loss.

Launchpad::_checkValidCapAndUpdate()

```
441  function _checkValidCapAndUpdate(uint256 _saleTokenAmount, uint256 _phaseNumber)
         internal {
442      PhaseInfo storage phaseInfo = phaseInfos[_phaseNumber - 1];

444      totalRaised += _saleTokenAmount;

446      if (totalRaised > maxRaiseAmount) revert RaisedMaxAmount();

448      uint256 amountOfTokensToBeAllocated = _tokenAllocBySale(_saleTokenAmount,
             phaseInfo);

450      totalAllocated += amountOfTokensToBeAllocated;
451      phaseInfo.allocatedAmount += amountOfTokensToBeAllocated;

453      if (
454          totalAllocated > max_launch_tokens_to_distribute
455          totalAllocated > phaseInfo.saleCap
456      ) revert NotEnoughToken();
457  }
```

Remediation   Add proper check to ensure the user can receive a reasonable amount of project token.

[L-3] Revisited Rewards Distribution Logic in ARBRewarder::setPool()

Target	Category	IMPACT	LIKELIHOOD	STATUS
ARBRewarder.sol	Business Logic	Medium	Medium	🔗Addressed

The `ARBRewarder` contract provides a public `setPool()` function for the privileged `owner` account to modify the key parameters of a staking pool. When examining its implementation logic, we notice that the distribution of pending rewards is incorrect under certain conditions.

To elaborate, we show the related code snippet below. Specifically, when the pool status remains active before and after parameter modification, but the `masterChef` address changes, the pending `ARB` rewards should be sent to the `rewarder` address obtained from the old `masterChef`, rather than being stored in the current contract and sent to the `rewarder` address obtained from the newly set `masterChef` during the next harvest operation.

ARBRewarder::setPool()

```
212     function setPool(address _stakingToken, address _masterChef, bool _isActive,
            uint256 _endTimestamp) external onlyOwner {

214         if(_masterChef == address(0))
215             revert ZeroAddress();
216         if (_endTimestamp < block.timestamp)
217             revert InvalidEndtime();

219         PoolInfo storage pool = tokenToPoolInfo[_stakingToken];

221         if (pool.isActive && !_isActive) {// if setting an active pool to
                inactive, queue the pending arb rewards to rewarder
222             address rewarder = IMasterMagpie(pool.masterChef).getRewarder(
                    _stakingToken);
223             _calculateAndSendARB(_stakingToken, rewarder);
224         }
225         if (!pool.isActive && _isActive) {// if setting an inactive pool as
                active, just set the current timestamp as lastRewardTimestamp
226             pool.lastRewardTimestamp = block.timestamp;
227         }
228         pool.masterChef = _masterChef;
229         pool.isActive = _isActive;
230         pool.endTimestamp = _endTimestamp;

232         emit SetPool(_stakingToken, _masterChef, _isActive, _endTimestamp);
233     }
```

Remediation For the scenario described above, timely send the pending `ARB` rewards to the `rewarder` address obtained from the old `masterChef` address.

[I-1] Improved Gas Efficiency in ARBRewarder::_calculateAndSendARB()

Target	Category	IMPACT	LIKELIHOOD	STATUS
ARBRewarder.sol	Coding Practices	N/A	N/A	🔗Addressed

The helper function `_calculateAndSendARB()` of the `ARBRewarder` contract is designed to calculate the pending `ARB` rewards and send the new rewards to be distributed to the `rewarder` contract. When examining its code implementation, we notice that the current gas usage could be further optimized. Specifically, by changing `tokenToPoolInfo[_stakingToken].lastRewardTimestamp = block.timestamp` to `pool.lastRewardTimestamp = block.timestamp` (line 135), the number of direct accesses to the state variable can be reduced, thereby saving gas.

ARBRewarder::_calculateAndSendARB()

```
115     function _calculateAndSendARB(address _stakingToken, address _rewarder)
            internal {

117         if(_rewarder == address(0))
118             return ;
119         PoolInfo storage pool = tokenToPoolInfo[_stakingToken];
120         if(!pool.isActive  pool.ARBPerSec == 0 )
121             return ;

123         uint256 multiplier = block.timestamp - pool.lastRewardTimestamp;
124         if (block.timestamp >= pool.endTimestamp){
125             pool.isActive = false;
126             multiplier = pool.endTimestamp - pool.lastRewardTimestamp;
127         }
128         uint256 rewardAmount = (multiplier * pool.ARBPerSec);
129         rewardAmount = Math.min(rewardAmount, ARB.balanceOf(address(this)));

131         ARB.approve(_rewarder, rewardAmount);
132         IBaseRewardPool(_rewarder).queueNewRewards(rewardAmount, address(ARB));

134         emit ARBRewadsSent(_stakingToken, _rewarder, rewardAmount, pool.
                lastRewardTimestamp, pool.ARBPerSec);
135         tokenToPoolInfo[_stakingToken].lastRewardTimestamp = block.timestamp;
136     }
```

Remediation   Reduce the number of direct accesses to the state variable by using `pool.lastRewardTimestamp = block.timestamp` instead of `tokenToPoolInfo[_stakingToken].lastRewardTimestamp = block.timestamp` (line 135).

4 | Appendix

4.1 About AstraSec

`AstraSec` is a blockchain security company that serves to provide high-quality auditing services for blockchain-based protocols. With a team of blockchain specialists, `AstraSec` maintains a strong commitment to excellence and client satisfaction. The audit team members have extensive audit experience for various famous DeFi projects. `AstraSec`'s comprehensive approach and deep blockchain understanding make it a trusted partner for the clients.

4.2 Disclaimer

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4.3 Contact

Phone	+86 156 0639 2692
Email	contact@astrasec.ai
Twitter	https://twitter.com/AstraSecAI