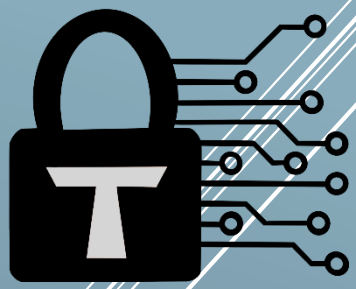
Trust Security

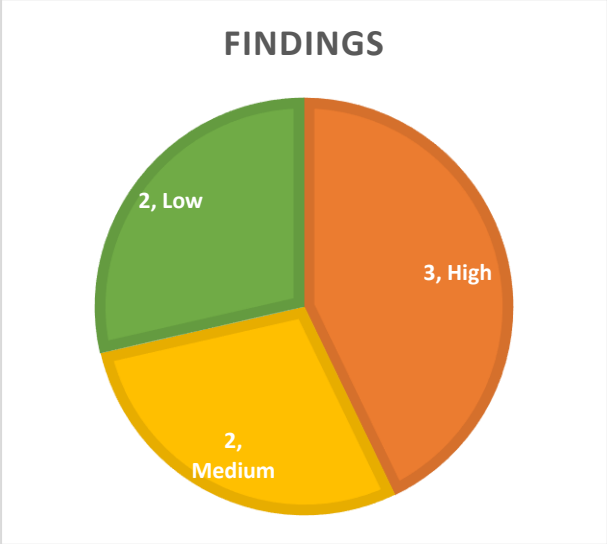


Smart Contract Audit

Hypercerts Marketplace

13/12/23

Executive summary

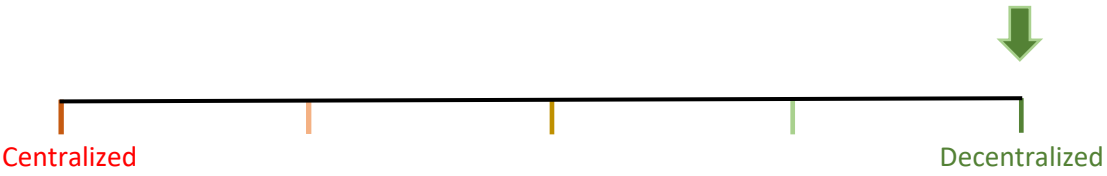


Category	Marketplace
Audit type	Differential audit
Auditor	Trust
Time period	04/12-13/12

Findings

Severity	Total	Open	Fixed	Acknowledged
High	3	1	2	-
Medium	2	1	1	-
Low	2	0	-	-

Centralization score



Signature

Digitally signed by Trust
Date: 2023.12.22 18:40:17 +02'00'

Document properties

Versioning

Version	Date	Description
0.1	13/12/23	Client report
0.2	22/12/23	Mitigation review

Contact

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Introduction

Trust Security has conducted an audit at the customer's request. The audit is focused on uncovering security issues and additional bugs contained in the code defined in scope. Some additional recommendations have also been given when appropriate.

Scope

All changes between the LooksRare commit forked and the commit hash below are considered in scope.

Repository details

- **Repository URL:** https://github.com/hypercerts-org/hypercerts
- **Commit hash:** 197968d71ff7782a4b3a9df8941666e8c466e7a9
- **Mitigation review commit hash:** 898b5bf1be6884790f4f1feb5ebbee4fb76fb4dc
- **Parent repository URL:** https://github.com/LooksRare/contracts-exchange-v2
- **Parent commit hash:** 7fca5650da653a2a0680e18e60164e639c18f830

About Trust Security

Trust Security has been established by top-end blockchain security researcher Trust, in order to provide high quality auditing services. Since its inception it has safeguarded over 30 clients through private services and over 30 additional projects through bug bounty submissions.

About the Auditors

Trust has established a dominating presence in the smart contract security ecosystem since 2022. He is a resident on the Immunefi, Sherlock and C4 leaderboards and is now focused in auditing and managing audit teams under Trust Security. When taking time off auditing & bug hunting, he enjoys assessing bounty contests in C4 as a Supreme Court judge.

Disclaimer

Smart contracts are an experimental technology with many known and unknown risks. Trust Security assumes no responsibility for any misbehavior, bugs or exploits affecting the audited code or any part of the deployment phase.

Furthermore, it is known to all parties that changes to the audited code, including fixes of issues highlighted in this report, may introduce new issues and require further auditing.

Methodology

In general, the primary methodology used is manual auditing. The entire in-scope code has been deeply looked at and considered from different adversarial perspectives. Any additional dependencies on external code have also been reviewed.

Qualitative analysis

Metric	Rating	Comments
Code complexity	**Good**	The code does not significantly increase the complexity of the forked codebase.
Documentation	**Good**	Project is mostly very well documented.
Best practices	**Good**	Project consistently adheres to industry standards.
Centralization risks	**Excellent**	Project does not introduce additional centralization risks.

Findings

High severity findings

TRST-H-1 A buyer can purchase more token units than the seller intended

- **Category:** Validation issues
- **Source:** StrategyHypercertFractionOffer.sol
- **Status:** Fixed

Description

In fraction offers, the maker provides the amount intended to be sold in **makerAsk.amounts[0]**. However, the strategy's processing logic only checks the collection's *unitsOf()* is above the taker's requested amount.

```
if (
    minUnitAmount > maxUnitAmount || unitAmount == 0 || unitAmount <
minUnitAmount || unitAmount > maxUnitAmount
        || pricePerUnit < makerAsk.price || makerAsk.price == 0
        || IHypercertToken(makerAsk.collection).unitsOf(itemIds[0]) <
unitAmount
) {
    revert OrderInvalid();
}
```

Suppose a user has 1000 tokens, and wishes to sell 499 of them, so they will always have majority vote in any governance based on the token units. An attacker can easily purchase 501 tokens and gain majority.

Recommended mitigation

Consider the maker's requested amount in the strategy validation.

Team response

The original design of the strategy is that the maker, i.e. seller, would split a fraction of the hypercert into a new fraction. The buyer would then purchase units of the new fraction until it holds 0 units. If a sale would by a portion of the available units a split would be initiated and the new fraction would be transferred to the buyer. If a sale would clear out the fraction (units would become 0), the strategy would then transfer the hypercert fraction to the buyer.

This implies the intention of the seller is to sell all available units. Admittedly, this can be confusing for users and indeed introduces risk to the seller.

To resolve the issue we changed the design of the strategy. Since a hypercert fraction in an NFT, the amounts field in the MakerAsk struct is required to be an array of size 1 with value 1. The additionalParameters field was expanded with minUnitsToKeep to declare the amount of units that should remain in the hypercert fraction. This has been tested in StrategyHypercertFractionOffer.sol.

Mitigation review

The fix is adding the condition below, that if true forces a revert of the order execution.

```
(IHypercertToken(makerAsk.collection).unitsOf(itemIds[0]) -
unitAmount) < minUnitsToKeep
```

Since units are split off on every fractional sell, the code guarantees at least **minUnitsToKeep** units remain at the maker's possession. Note that if the maker increases their unit balance after creating the order, the increased units can also be sold off, so if that is not the intention they are required to invalidate the order before increasing their balance.

TRST-H-2 The fraction offer maker order is not invalidated correctly, leading to orders being replayed

- **Category:** Logical flaws
- **Source:** StrategyHypercertFractionOffer.sol
- **Status:** Fixed

Description

The marketplace supports three nonce types, including a per-order nonce which allows orders to be executed multiple times for partially filled orders. The **isNonceInvalidated** return value indicates the intention, below is the calculation in the fraction offer.

```
// If the amount to fill is equal to the amount of units in the
hypercert, we transfer the fraction.
// Otherwise, we do not invalidate the nonce because it is a partial
fill.
isNonceInvalidated =
IHypercertToken(makerAsk.collection).unitsOf(itemIds[0]) ==
unitAmount;
```

The nonce is only invalidated when the purchased amount (**unitAmount)** equals the total supply of the **itemID**. The logic is only sound under two assumptions:

- The user intended to sell the entire supply (an assumption also covered in H-1)
- The entire amount is purchased in a single order

For example, if a user intended to sell 50 units, and two buyers buy 1 and 49 units respectively, the order will remain valid. Suppose a user is interested in buying and holding tokens at a future point. An attacker can replay the previous maker order and purchase them at the previous price.

Recommended mitigation

Consider the remaining amount to be purchased at all time and invalidate when that amount is reduced to zero.

Team response

We've updated the logic to invalidate the order to test against the change in balance when the strategy would execute.

This has been tested in StrategyHypercertFractionOffer.sol under testMakerAskInvalidation where we execute multiple sales to invalidated the order, add additional units to the original hypercert fraction and execute a sale to validate that the order still cannot be executed because the nonce of the order has been invalidated.

Additionally, to underline the paradigm of 'fractions are NFTs` we've updated the OrderValidatorV2A to not check on the units held by the fraction, but whether the fraction is owned by the maker. Check on the units held by the fraction is still done in the strategy.

Mitigation review

The nonce is correctly invalidated when all desired units have been exchanged.

TRST-H-3 When Hypercerts are traded in Collection or Dutch auction offers, one of the sides can provide a lower unit amount than expected

- **Category:** Logical flaws
- **Source:** StrategyCollectionOffer.sol,StrategyDutchAuction.sol
- **Status:** Open

Description

The marketplace supports trading of Hypercerts through the Collection and Dutch auction strategies. In this case they are viewed strictly as ERC1155s with an implicit **amount=1** enforced through the Hypercerts token contracts.

The strategies would function correctly for Hypercerts as long as the buyer and seller are in-sync on the amount of units transferred. However, it can be proven that can never be guaranteed to be the case, as Hypercert tokens can always be split by their owner.

Consider a Dutch auction for a Hypercert currently with 1000 units. A buyer may fill the order assuming they will receive 1000 units. However, the seller frontruns the order fill with a division of the units, so that 999 units are transported to a new **tokenID**, while 1 unit remains. The buyer therefore pays 1000x more than they expected per unit.

Recommended mitigation

The Hypercert implementation of pre-existing strategies must fork off and account for Hypercert units.

Team response

Following the recommendation, we've split the CollectionOffer and dutchAuctionOffer strategies into two separate strategies for ERC721/ERC1155 and hypercerts.

Mitigation review

New issues have been observed in the Dutch implementation. In the order validation routine, the amounts are validated to be zero:

```
for (uint256 i; i < itemIdsLength;) {
    _validateAmountNoRevert(makerAsk.amounts[i],
makerAsk.collectionType);
```

However, in the actual strategy execution, this check is not performed:

```
for (uint256 i; i < unitsPerItemLength;) {
    if
(IHypercertToken(makerAsk.collection).unitsOf(makerAsk.itemIds[i]) !=
unitsPerItem[i]) {
        revert OrderInvalid();
    }
    unchecked {
        ++i;
    }
}
```

This is an informational issue because an amount that is not one will revert at the time of transfer, in *transferItermsHypercert()*.

A more serious issue is that a Dutch order can still be abused by the maker to transfer less units than intended. The source of the problem is a time-of-check, time-of-use flaw, as the unit count transferred is only checked during strategy execution, but that amount can change by the time the Hypercert is transferred.

To elaborate, the code below verifies the advertised units per item are the complete unit count:

```
for (uint256 i; i < unitsPerItemLength;) {
    if
(IHypercertToken(makerAsk.collection).unitsOf(makerAsk.itemIds[i]) !=
unitsPerItem[i]) {
        revert OrderInvalid();
    }
    unchecked {
        ++i;
    }
}
```

Then, in *_executeTakerBid()*, payment goes to the recipient, which is the maker.

```
// Taker action goes first
_transferToAskRecipientAndCreatorIfAny(recipients, feeAmounts,
makerAsk.currency, sender);
```

At this point the recipient can receive code execution, as tokens are transferred to him. For example, if payment is made in Hypercerts or ERC1155, the 1155 callback will be called.

```
function _transferFungibleTokens(address currency, address sender,
address recipient, uint256 amount) internal {
    if (currency == address(0)) {
        _transferETHAndWrapIfFailWithGasLimit(WETH, recipient,
amount, _gasLimitETHTransfer);
    } else {
        _executeERC20TransferFrom(currency, sender, recipient,
amount);
    }
}
```

Finally, the Hypercert transfer will proceed.

```
// Maker action goes second
_executeTakerBidMakerAction(makerAsk, takerBid, signer, sender,
itemIds, amounts);
```

```
if (makerAsk.collectionType == CollectionType.Hypercert) {
     _transferHypercertFraction(
         makerAsk.collection,
         makerAsk.collectionType,
         makerAsk.strategyId,
         sender,
         takerBid.recipient == address(0) ? recipient :
takerBid.recipient,
         itemIds,
         amounts
     );
```

This would end up transferring ownership of the Hypercert, but it never checks that the **unitsPerItem** declared in the maker bid is actually transferred. A malicious user can transfer all but one unit out of the tokenID to complete the exploit.

Another issue has been observed in the customized legacy strategies. Note that Hypercerts units can be donated to other tokenIDs inside the same base type. This means that any logic that assumes an order maker's token amount is controlled by them is fragile. For example, consider the Dutch auction. The maker is committing to selling **unitsPerItem** list of units of the predefined types. These must equal the total unit amount of that itemID, meaning no fractional transfers are supported.

```
uint256 unitsPerItemLength = unitsPerItem.length;
for (uint256 i; i < unitsPerItemLength;) {
    if
(IHypercertToken(makerAsk.collection).unitsOf(makerAsk.itemIds[i]) !=
unitsPerItem[i]) {
        revert OrderInvalid();
    }
    unchecked {
        ++i;
    }
}
```

So, an attacker may invalidate a running auction by donating a single Hypercert token unit of the same base type, by calling *mergeFractions()*. At this point, the Dutch auction can no longer complete, as the *unitsOf()* has increased by one.

Medium severity findings

TRST-M-1 An attacker could grief buyer into getting a lower-valued item than intended

- **Category:** Validation flaws

- **Source:** StrategyCollectionOffer.sol
- **Status:** Fixed

Description

Hypercerts introduced the following strategy in StrategyCollectionOffer:

```
function executeCollectionStrategyWithTakerAskWithAllowlist(
    OrderStructs.Taker calldata takerAsk,
    OrderStructs.Maker calldata makerBid
)
```

The taker provides the **itemID** offered from the collection, the payment **recipient**, and a Merkle proof of the recipient's existence in the maker's Merkle tree. The issue is that anyone can execute the trade on recipient's behalf and pass a lower-valued **itemID**. The maker would end up overpaying as they assumed **recipient** would not offer a low-value item (they are whitelisted). The attacker does not stand to gain as they would need to provide the item whilst the payment goes to the whitelisted recipient. However due to the negative consequences for the maker and the possibly low cost of attack, the issue is still substantial.

Recommended mitigation

The taker parameters should additionally provide the recipient's signature over the **itemID** passed. Care should be taken to avoid any replay attacks.

Team response

Following the recommendation, we've added signed messages to the StrategyHypercertFractionOffer.sol strategy. This entailed adding signed message parsing and updating the corresponding tests cases as well.

Mitigation review

The signature scheme is implemented safely.

TRST-M-2 Fraction offers can be blocked from being fully fulfilled

- **Category:** Logical flaws
- **Source:** StrategyHypercertFractionOffer.sol
- **Status:** Open

Description

The Hypercerts marketplace supports selling of arbitrary-size fractions of a Hypercert until it is wholly consumed. The strategy checks the amount purchased is within the maker's defined minimum and maximum amount and that the price is not lower than the requested price.

```
//units, pricePerUint
(uint256 unitAmount, uint256 pricePerUnit) =
abi.decode(takerBid.additionalParameters, (uint256, uint256));
//minUnitAmount, maxUnitAmount, root
(uint256 minUnitAmount, uint256 maxUnitAmount) =
abi.decode(makerAsk.additionalParameters, (uint256, uint256));
// A collection order can only be executable for 1 itemId but
```

```
quantity to fill can vary
if (
    minUnitAmount > maxUnitAmount || unitAmount == 0 || unitAmount <
minUnitAmount || unitAmount > maxUnitAmount
        || pricePerUnit < makerAsk.price || makerAsk.price == 0
        || IHypercertToken(makerAsk.collection).unitsOf(itemIds[0]) <
unitAmount
) {
    revert OrderInvalid();
}
```

Suppose that a holder wishes to sell 1000 units, at batches of size 100-200. After several sales, the remaining quantity is 99 units. This could occur naturally or base an attacker carefully picking a purchase amount. At this point, the holder cannot sell the remaining units under that order.

Recommended mitigation

Consider allows amounts less than **minUnitAmount** if they are the last portion of the order.

Team response

The StrategyHypercertFractionOffer.sol strategy has been updated to allow the maker to set whether they want to sell the leftover units.

We find that it's expected behaviour that you can be left over with a bit of the fraction, but can understand that this can be confusing for users. The parameter sellLeftover has been added to the additionalParameters field of the MakerAsk struct. If set to true the strategy will sell the leftover units to the taker.

Mitigation review

The fix has been implemented using the **sellLeftover** variable, used below:

```
if (sellLeftover) {
    if (
        minUnitAmount > maxUnitAmount || unitAmount == 0 ||
unitAmount > maxUnitAmount
            || pricePerUnit < makerAsk.price || makerAsk.price == 0
            ||
(IHypercertToken(makerAsk.collection).unitsOf(itemIds[0]) -
unitAmount) < minUnitsToKeep
    ) {
        revert OrderInvalid();
    }
} else {
    if (
        minUnitAmount > maxUnitAmount || unitAmount == 0 ||
unitAmount < minUnitAmount
            || unitAmount > maxUnitAmount || pricePerUnit <
makerAsk.price || makerAsk.price == 0
            ||
(IHypercertToken(makerAsk.collection).unitsOf(itemIds[0]) -
unitAmount) < minUnitsToKeep
    ) {
        revert OrderInvalid();
    }
}
```

Note that if **sellLeftover** is true, there is no check for **unitAmount < minUnitAmount**. However this check should still be applied in all but the last sale. In the current implementation, the **minUnitAmount** becomes devoid of meaning.

Low severity findings

TRST-L-1 The strategy validation function for fraction sales could revert

- **Category:** Validation issues
- **Source:** StrategyHypercertFractionOffer.sol
- **Status:** Fixed

Description

The *isMakerOrderValid()* function is implemented for every strategy and should return a **true** or **false** response. The following check in the fraction sale strategy isn't safe.

```
if (
    makerAsk.amounts.length != 1 || makerAsk.amounts[0] == 0
        ||
IHypercertToken(makerAsk.collection).unitsOf(makerAsk.itemIds[0]) <
makerAsk.amounts[0]
        || makerAsk.itemIds.length != 1 || minUnitAmount >
maxUnitAmount || makerAsk.price == 0
        || maxUnitAmount == 0
) {
    return (isValid, OrderInvalid.selector);
}
```

The key detail is that the **itemIds** array is accessed at index 0 before checking the array length. Therefore, on an empty array, the function would revert instead of returning **false**.

Recommended mitigation

Reverse the order of the validation checks.

Team response

Fixed.

Mitigation review

Issue fixed as suggested.

TRST-L-2 Hypercert orders with invalid amount will pass validations

- **Category:** Validation issues
- **Source:** BaseStrategy.sol
- **Status:** Fixed

Description

All strategies inherit from BaseStrategy and in their *isValidMakerOrder()* function, call the parent *validateAmountNoRevert()*:

```
/**
 * @dev This is equivalent to
 *      if (amount == 0 || (amount != 1 && collectionType == 0)) {
 *          return (0, OrderInvalid.selector);
 *      }
 * @dev OrderInvalid_error_selector is a left-padded 4 bytes. If the
error selector is returned
 *      instead of reverting, the error selector needs to be right-
padded by
 *      28 bytes. Therefore it needs to be left shifted by 28 x 8 =
224 bits.
 */
function _validateAmountNoRevert(uint256 amount, CollectionType
collectionType) internal pure {
    assembly {
        if or(iszero(amount), and(xor(amount, 1),
iszero(collectionType))) {
            mstore(0x00, 0x00)
            mstore(0x20, shl(224, OrderInvalid_error_selector))
            return(0, 0x40)
        }
    }
}
```

The function validates the order **amount**, and in case the collection is an NFT, it must be 1. However, since Hypercerts always have the ERC1155 **amount=1**, the validation should also perform that check for CollectionType.Hypercert.

Recommended mitigation

Consider improving validation of Hypercerts as suggested above.

Team response

Added additional logic check in assembly to _validateAmountNoRevert and implemented the method in the hypercert strategies.

Mitigation review

The validation has been improved.

Additional recommendations

TRST-R-1 Improve validation of orders in fraction offers

In the Hypercert fraction offer, *isMakerOrderValid()* checks the additional parameters byte array size is correct when using the allow list strategy.

```
if (
    functionSelector
        ==
StrategyHypercertFractionOffer.executeHypercertFractionStrategyWithTa
kerBidWithAllowlist.selector
        && makerAsk.additionalParameters.length != 96
) {
    return (isValid, OrderInvalid.selector);
}
isValid = true;
```

It is advised to have similar validation for the *executeHypercertFractionStrategyWithTakerBid()* strategy as well.

Centralization risks

No centralization risks have been introduced on top of the LooksRare codebase.

Systemic risks

TRST-SR-1 Risks associated with Hypercerts

The marketplace supports working with Hypercert tokens, which involve inherent systemic risks. Most importantly they are upgradable, meaning any behavior that can be expected of Hypercerts can break if the owner opts for an upgrade, or is compromised.