Regulatory Analysis of Trust-Less Non-Custodial Atomic Swap Bridges Under the Markets in Crypto-Assets (MiCA) Regulation

1. Executive Summary

The promulgation of the Regulation (EU) 2023/1114 on Markets in Crypto-Assets (MiCA) marks a watershed moment in the global supervision of digital finance, establishing a harmonized framework that rigorously defines the perimeter of regulated activity within the European Economic Area. This report provides an exhaustive legal and technical analysis of a specific, high-stakes architectural paradigm: a trust-less, non-custodial bridge facilitating atomic swaps between blockchain networks (specifically examining the Cardano and Monero ecosystems), utilizing peer-to-peer (P2P) discovery mechanisms and Tor-protected rendezvous points.

The core of this inquiry rests on the tension between the concept of "fully decentralized" services—which are nominally exempt under Recital 22 of MiCA—and the functional definitions of Crypto-Asset Service Providers (CASPs). Through a comparative analysis of two distinct technological approaches—the pure atomic swap model (exemplified by UnstoppableSwap) and the federated bridge model (exemplified by Rosen Bridge)—this report demonstrates a bifurcated regulatory reality.

The analysis indicates that pure atomic swap protocols, which function as software-based bulletin boards for P2P discovery without centralized matching engines or custodial intermediaries, likely fall outside the CASP definition. In contrast, federated bridge architectures that rely on "Watchers" and "Guards" to secure cross-chain collateralization, particularly those incentivized by governance tokens (RSN) and fees, face a substantial probability of being classified as CASPs. This classification is triggered by the professional nature of the service and the functional custody exercised through multi-signature wallet schemes. Furthermore, the integration of Monero (XMR)—a privacy-preserving asset—introduces a critical compliance impasse. The strict Anti-Money Laundering (AML) and Transfer of Funds Regulation (TFR) obligations imposed on CASPs are fundamentally incompatible with Monero's obfuscation protocols, rendering the compliant operation of a CASP-mediated Monero bridge legally practically impossible within the European Union.

2. The MiCA Regulatory Perimeter: Definitions and Jurisdictional Scope

To determine the licensure obligations of a Cardano/Monero atomic swap bridge, one must first deconstruct the definitions governing the scope of MiCA. The regulation moves beyond the "entity-based" regulation of traditional finance to an "activity-based" approach, capturing any natural or legal person whose business is the provision of crypto-asset services.

2.1 The Definition of a Crypto-Asset Service Provider (CASP)

Under Article 3(1)(15) of MiCA, a CASP is defined broadly as a legal person or other undertaking whose occupation or business is the provision of one or more crypto-asset services to clients on a professional basis.[1] This definition hinges on three critical components: the existence of a legal person or undertaking, the existence of a client relationship, and the professional nature of the activity.

The regulation explicitly enumerates ten distinct services that trigger the requirement for authorization. For the purposes of a cross-chain bridge and swap architecture, four of these services are of paramount relevance:

1. **The Operation of a Trading Platform for Crypto-Assets:** This is defined as the management of a system that brings together multiple third-party buying and selling interests in crypto-assets, in a way that results in a contract.[4] This definition draws heavily from the MiFID II definition of Multilateral Trading Facilities (MTFs).
2. **The Exchange of Crypto-Assets for Other Crypto-Assets:** This covers the conclusion of purchase or sale contracts concerning crypto-assets with clients for other crypto-assets by using proprietary capital.[1] This is the classical "dealer" or "market maker" model.
3. **Custody and Administration of Crypto-Assets on Behalf of Clients:** This involves the safekeeping or controlling, on behalf of clients, of crypto-assets or the means of access to such crypto-assets, primarily in the form of private cryptographic keys.[4]
4. **Reception and Transmission of Orders (RTO):** This entails receiving an order to buy or sell a crypto-asset from a client and transmitting that order to a third party for execution.[7]

2.2 The "Fully Decentralized" Exemption (Recital 22)

The legal defense for many DeFi protocols rests on Recital 22 of MiCA. This recital clarifies that where crypto-asset services are provided in a "fully decentralized manner without any intermediary," they should not fall within the scope of the regulation.[9] The text explicitly

acknowledges that the regulation applies to "natural and legal persons and certain other undertakings," implying that a software protocol lacking a central operator might escape the CASP net.[9]

However, the interpretation of "fully decentralized" is extremely narrow. Regulatory guidance from the European Securities and Markets Authority (ESMA) and academic analysis suggests that even partial centralization—such as the presence of a governance DAO with a legal wrapper, a development team retaining administrative keys, or a frontend operator—can void this exemption.[11] If an entity or "undertaking" can be identified as providing the service "on a professional basis," the decentralized defense fails.

The concept of an "undertaking" in EU law is broad, encompassing any entity engaged in an economic activity, regardless of its legal status or the way it is financed. This suggests that even a DAO without a formal corporate structure could be classified as an "undertaking" if it generates revenue (e.g., protocol fees) and distributes it to participants (e.g., token holders).[3]

2.3 The "Professional Basis" Threshold

A crucial determinant for CASP classification is whether the service is provided "on a professional basis".[1] While not strictly defined in the text of MiCA, broader EU financial jurisprudence suggests this encompasses activities carried out for remuneration, on a continuous basis, or as part of a commercial strategy.[3]

This creates a significant distinction in the bridge ecosystem. A hobbyist running a node to support the network without profit expectation might not be a CASP. However, a "Relayer" or "Watcher" running sophisticated infrastructure to earn fees or yield from a governance token (like the RSN token in the Rosen Bridge architecture) is almost certainly operating on a professional basis.[13] The "professional" element transforms a participant from a mere user of software into a regulated service provider.

3. Architectural Case Study A: The UnstoppableSwap Model

To analyze the regulatory implications of a "trust-less" bridge, we first examine the architecture of UnstoppableSwap, which facilitates Bitcoin-to-Monero swaps. While the user query specifies Cardano, the UnstoppableSwap architecture represents the archetype of the "pure" atomic swap, which is technically replicable for Cardano/Monero pairings given the appropriate cryptographic primitives (such as HTLCs or adaptor signatures).

3.1 Technical Mechanics of the Atomic Swap

UnstoppableSwap operates on a "Maker-Taker" model designed to be trustless and non-custodial. The core mechanism is the atomic swap, which ensures that the exchange of assets happens simultaneously or not at all, eliminating counterparty risk without a third-party custodian.[15]

In this architecture, the "Maker" runs a specialized software component known as the Automated Swap Backend (ASB). This ASB communicates directly with the blockchain nodes (e.g., monero-wallet-rpc for Monero and electrs for Bitcoin) to monitor the chain state and execute the swap scripts.[17] The "Taker" (the user) interacts with a client that discovers these Makers. Crucially, the swap is executed via Hash Time-Locked Contracts (HTLCs) or similar script-based constraints on-chain.[15]

The discovery mechanism—how the Taker finds the Maker—utilizes a peer-to-peer network. UnstoppableSwap employs a distributed order book, often propagated via a gossip protocol or a specialized network like the SMSG (Secure Multiparty Structured Grids) network.[17] This ensures that no central server holds the order book; rather, every peer maintains a local copy of the offers broadcast by Makers.

3.2 Regulatory Analysis: The Trading Platform vs. Bulletin Board Distinction

The critical regulatory question for the UnstoppableSwap model is whether the discovery mechanism constitutes "operating a trading platform."

ESMA and national regulators distinguish between "matching" systems and "bulletin boards."

- **Trading Platform (Regulated):** A system that uses an automated matching engine to execute trades between buying and selling interests.[18] If the software automatically pairs a Maker and a Taker and executes the trade, it operates a platform.
- **Bulletin Board (Exempt):** A system that merely aggregates and displays buying and selling interests (advertisements), leaving the users to settle the transaction bilaterally and often outside the system.[18]

Verdict: The UnstoppableSwap architecture, where Makers broadcast offers via a P2P network and Takers *manually* select an offer to initiate an atomic swap, aligns closely with the "bulletin board" exemption. There is no central entity "operating" the matching engine; the matching is a function of the Taker's manual selection and the cryptographic protocol.[18] The software developers provide the tool (the protocol), but they do not operate the market. Consequently, the software developers likely do not require a CASP license for "operating a trading platform."

3.3 Custody and Liability of Makers

The definition of custody under MiCA requires the control of private keys.[4] In the

UnstoppableSwap model, neither the developers nor any network nodes hold the user's funds. The funds are locked in smart contracts controlled solely by the user's private key and the cryptographic secret of the swap.[15] Thus, the "custody and administration" license is not applicable to the protocol.

However, a nuanced risk arises for the **Makers**. While the protocol is exempt, the individual entities running the Automated Swap Backend (ASB) to provide liquidity are engaging in "exchange of crypto-assets for other crypto-assets".[1] If these Makers are doing so on a professional basis (e.g., high-frequency algorithmic trading to capture spreads), they may technically be proprietary traders. While proprietary trading is generally exempt under MiCA (Article 4(6) MiFID analogy), it becomes regulated if the Maker is deemed to be "executing orders on behalf of clients" or operating as a market maker for the public.[1] For a decentralized network of anonymous Makers, enforcement is difficult, but legally, a high-volume professional Maker could be classified as an unauthorized CASP.

4. Architectural Case Study B: The Rosen Bridge Model

The second architectural paradigm, often referenced in the context of Cardano interoperability, is the federated bridge model exemplified by the Rosen Bridge. This system connects chains like Cardano, Ergo, and Bitcoin (and potentially Monero via similar logic) using a "Watcher" and "Guard" consensus mechanism.[22] This architecture presents a significantly different risk profile under MiCA.

4.1 Technical Mechanics: Watchers, Guards, and the RSN Token

Unlike the atomic swap model which relies on mathematical locks (HTLCs), Rosen Bridge relies on a federated consensus.
- **Watchers:** These are open-source actors who monitor the source chain (e.g., Cardano) for deposit events. When a user locks funds, Watchers report this event to the Ergo blockchain.[23]
- **Guards:** These are a defined set of entities (a federation) that verify the reports from Watchers. If a consensus is reached (m-out-of-n), the Guards sign a transaction to release or mint the corresponding asset on the destination chain.[23]
- **RSN Token:** The security of the system is economic. Watchers must stake (lock) RSN tokens and Ergo (ERG) as collateral to acquire "reporting permits." Guards also lock RSN. Successful operations generate rewards (fees) paid in RSN, while malicious behavior results in slashing (loss of collateral).[25]

4.2 Regulatory Analysis: The "Guard Set" as a Custodial CASP

The most precarious legal element of the Rosen Bridge is the role of the Guards. The Guards collectively control a multi-signature wallet (or threshold signature scheme) on the connected chains.[23]

The ESMA Guidelines on Multi-Sig Custody:

ESMA has provided explicit guidance that "safekeeping services" include situations where an entity controls private keys on behalf of clients. Crucially, ESMA notes that "multi-signature wallets, where several private keys held by different individuals instead of one are needed for a transaction to happen, will also require consideration" and generally fall within the scope of custody if the service provider (the federation) effectively controls the asset movement.[27] Unlike the atomic swap where the user retains ultimate control via a timelock refund, in the Rosen Bridge, the user transfers assets to a wallet controlled by the Guard Set. The user is trusting the consensus of the Guards to release the funds. This constitutes "custody and administration of crypto-assets on behalf of clients".[4]

Verdict: The entities acting as Guards are likely operating as a CASP. Because the Guards are a distinct, identifiable group (often vetted or permissioned in the early stages, though the goal is decentralization), they fit the definition of an "undertaking." The fact that they utilize a multi-sig arrangement does not absolve them of custodial liability under MiCA; rather, it confirms it.

4.3 The "Professional Basis" of Watchers and the RSN Token

The involvement of the RSN token further cements the "professional" nature of the service.
- **Economic Incentives:** Watchers and Guards are not passive volunteers; they are economic agents posting collateral (RSN) and earning fees.[14] This satisfies the "on a professional basis" criteria for CASP classification.[3]
- **Transfer Services:** The Watchers are integral to the "transfer services for crypto-assets" defined in MiCA Article 3(1)(17b). They facilitate the movement of assets from one address to another.[8] While Recital 63d of MiCA exempts "validators, nodes or miners that may be part of confirming a transaction," Watchers in a bridge are distinct from Layer 1 validators. They are providing a specific cross-chain service, not merely securing the underlying ledger. This makes the exemption tenuous at best for bridge-specific actors.[21]

4.4 The Role of the Ergo Foundation

The governance structure also impacts liability. The Ergo Foundation, a non-profit entity, supports the development of Rosen Bridge.[29] If the Foundation is seen as the "operator" or the entity organizing the Guard Set, it could be targeted as the CASP. However, if the Foundation merely contributes code and the Guards operate independently, the liability shifts

to the individual Guards. The centralization of the "Guard Set" (even if federated) presents a clear target for regulators compared to the ephemeral P2P nature of UnstoppableSwap.

5. The Monero Paradox: Privacy Coins Under MiCA

The integration of Monero (XMR) into either of these bridge architectures creates a severe conflict with the Anti-Money Laundering (AML) and Counter-Terrorist Financing (CFT) provisions embedded in MiCA and the Transfer of Funds Regulation (TFR).

5.1 The Prohibition on Anonymity

Monero utilizes Ring Signatures, Stealth Addresses, and RingCT to obfuscate the sender, receiver, and amount of every transaction.[22] This "inbuilt anonymization" is antithetical to the obligations of a CASP.

Article 76 of MiCA and the accompanying TFR rules generally prohibit CASPs from keeping anonymous accounts or facilitating transactions where the beneficial owners cannot be identified.[31] The "Travel Rule" requires CASPs to collect and transmit originator and beneficiary information for all transfers.[33]

The Compliance Impossibility:

For a CASP (like a Rosen Bridge Guard Set), facilitating a Monero transfer would require identifying the owner of the Monero address. However, the very nature of Monero prevents the CASP from verifying the source of funds on-chain without the user surrendering their private view keys, which is not a standard part of bridge interactions. Furthermore, the inability to trace the history of the XMR coins exposes the CASP to massive AML liability.

- **Regulatory Consequence:** A compliant CASP operating in the EU would likely be forced to delist or block Monero to maintain its license.[31] This renders a *compliant* Rosen Bridge for Monero legally impossible under current EU rules.

5.2 The Self-Hosted Wallet Exemption

The TFR currently exempts peer-to-peer transfers between "self-hosted wallets" (non-custodial wallets) where no CASP is involved.[34]

- **Implication for UnstoppableSwap:** Because UnstoppableSwap is non-custodial and involves direct P2P transfers between users (via atomic swaps), it leverages this exemption. If the software is truly decentralized and the makers are not CASPs, the TFR obligations do not apply to the protocol code.[33] This makes the atomic swap model the *only* legally viable architecture for Monero interoperability in the EU, precisely because it avoids the CASP classification that triggers the ban on privacy coins.

6. Infrastructure Liability: Relayers, Discovery, and Tor

The modern DeFi stack relies on "middleware" infrastructure—discovery nodes, relayers, and frontends—which operates in a regulatory grey zone.

6.1 P2P Discovery and "Reception and Transmission of Orders"

In the UnstoppableSwap model, "discovery nodes" or the SMSG network facilitate the broadcasting of offers.[17]

- **RTO Analysis:** MiCA defines "Reception and Transmission of Orders" (RTO) as receiving an order and transmitting it to a third party for execution.[7] If a discovery node merely propagates encrypted messages (like a router) without being able to access the content or match the trade, it is likely infrastructure.[8]
- **The "Arranging Deals" Risk:** Drawing from UK FCA guidance (which often informs EU interpretation), activities that "arrange deals" or bring parties together with a view to a transaction can be regulated.[36] If a node operator creates a curated list of "trusted Makers" or filters orders for a fee, they move from passive infrastructure to active intermediary, potentially triggering the RTO classification.[38]

6.2 Tor Hidden Services and Frontend Liability

The case study specifies "Tor-protected rendezvous points." Hosting a Tor hidden service acts as a shield for the IP address of the Maker.[39]

- **Frontend Liability:** A major enforcement trend is targeting the operators of "frontends" (web interfaces) even if the protocol is decentralized. ESMA and other bodies increasingly view the operation of a web interface that allows easy access to a protocol as a regulated activity, specifically RTO.[40]
- **Application:** If the "bridge" is accessed via a website hosted by a team, that team is liable. If the bridge is a downloadable desktop client (like the UnstoppableSwap app) that connects directly to Tor, the developers are merely publishing code. The absence of a hosted "service" creates a stronger defense against CASP classification.[20] However, "reverse solicitation" rules are strict; simply having a website accessible to EU users (even if hosted outside) without active blocking can trigger compliance requirements.[41]

6.3 Relayers and the "Transfer Service" Trap

In bridge architectures, "Relayers" often pass messages between chains.

- **Regulatory View:** While industry advocates argue Relayers are just IT infrastructure [43], MiCA's definition of "transfer services" is broad. If a Relayer is essential to the movement of value and takes a fee, they may be captured. [21] The defense lies in Recital 63d, but this is untested for cross-chain bridges.

7. Comparative Analysis: Architecture vs. Regulation

The following table summarizes the regulatory exposure of the two architectures under the key MiCA pillars.

Regulatory Pillar	UnstoppableSwap (Pure Atomic Swap)	Rosen Bridge (Federated/Watchers)
Custody (Art. 3(1)(15))	**Exempt.** Non-custodial; users hold keys. [15]	**Likely CASP.** Guard Set controls multi-sig. [27]
Trading Platform	**Exempt.** Bulletin board model; manual selection. [18]	**Ambiguous.** Depends on if Guards match/route.
Intermediary Status	**None.** Direct P2P interaction.	**High.** Guards/Watchers are intermediaries. [3]
Tokenomics/Profit	**None.** No governance token required.	**Regulated.** RSN token implies professional basis. [13]
AML/Monero Status	**Viable (Gray).** P2P exemption applies (TFR). [35]	**Prohibited.** CASP cannot support XMR. [31]
Decentralized Exemption	**Strong Claim.** Recital 22 applies to code.	**Weak Claim.** Identifiable federation exists. [11]

7.1 Global Context: The UK Comparison

It is instructive to briefly contrast this with the UK approach. The UK Treasury's consultation on crypto-assets focuses heavily on "arranging deals in investments".[36] While the EU focuses on the "CASP" entity definition, the UK focus on "arranging" could capture even the developers of P2P software if they are seen as "making arrangements with a view to transactions".[37] However, both jurisdictions generally respect the distinction between "software development" (exempt) and "operating a service" (regulated).[36]

8. Strategic Implications and Future Outlook

The analysis leads to a clear bifurcation in the future of cross-chain infrastructure under

MiCA.

8.1 The Bifurcation of the Market

We are witnessing the emergence of two distinct bridge categories:
1. **The Regulated Enterprise Bridge:** Architectures like Rosen Bridge, which have identifiable governance, revenue models (tokens), and custodial elements (Guards), will be forced to seek CASP licensure. To achieve this, they will likely be forced to drop privacy coins like Monero and implement strict KYC/KYT (Know Your Transaction) on all users, fundamentally altering their value proposition.
2. **The Dark/Grey P2P Protocol:** Protocols like UnstoppableSwap will likely remain unlicensed, relying on the "fully decentralized" exemption. They will exist as pure software tools (bulletin boards) without centralized frontends or governance tokens. Their survival will depend on their ability to resist "frontend liability" by avoiding hosted web interfaces and relying solely on locally run desktop clients connecting via Tor.

8.2 The Threat of "De-Anonymization"

Even for P2P protocols, the technical risk of de-anonymization remains a legal vector. Research indicates that timing analysis and address clustering can trace P2P swap activity.[16] If regulators can identify the high-volume Makers in an atomic swap network, they will target them as unauthorized "market makers" dealing on a professional basis, effectively attacking the liquidity supply of the network rather than the protocol developers.[1]

9. Conclusion

The regulatory classification of a Cardano/Monero atomic swap bridge under MiCA is not a binary outcome but a spectrum determined by architectural centralization and economic incentives.

The **pure atomic swap model** (UnstoppableSwap), characterized by non-custodial HTLCs, P2P discovery, and a lack of governance tokens, presents the strongest case for exemption under Recital 22 as a "fully decentralized" software tool. It functions legally as a bulletin board, allowing it to bypass the CASP licensing regime and, by extension, the prohibition on Monero.

Conversely, the **federated bridge model** (Rosen Bridge), characterized by a consensus of "Guards" holding multi-sig keys and "Watchers" incentivized by RSN tokens, exhibits the hallmarks of a "professional" service provider. The custodial nature of the Guard Set and the economic activity of the Watchers trigger the CASP definition. For such an entity, MiCA licensure is mandatory, and the consequent AML obligations would necessitate the exclusion of Monero, thereby negating the specific utility of the bridge for privacy-preserving

cross-chain swaps.

Therefore, for a trust-less non-custodial bridge to operate legally with Monero in the EU without a license, it must rigidly adhere to the "software-only" paradigm: no hosted frontend, no governance token, no custodial federation, and a strictly peer-to-peer discovery mechanism. Any deviation toward managed services or incentivized infrastructure invites the full weight of the MiCA regulatory framework.

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