MastChain: A Decentralized Protocol for Verifiable AIS Data

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Abstract

AIS (Automatic Identification System) data is the foundation of global maritime visibility, essential for everything from port logistics and insurance underwriting to real-time cargo tracking, environmental compliance, and financial trade analysis. As over 90Today, AIS data is aggregated and sold by centralized platforms, many of which rely heavily on volunteers and hobbyists to provide terrestrial coverage. These contributors receive no financial reward, and are typically only offered access to premium tools in exchange for meeting uptime targets. Meanwhile, the platforms they support monetize the data, often without ensuring its authenticity. The system is vulnerable to data manipulation, tampering, and patchy coverage, particularly in underdeveloped regions. MastChain is a decentralized data layer that fixes this broken model. It rewards contributors with MAST tokens for submitting valid AIS data, using on-chain consensus to verify accuracy, freshness, and geographic coverage. The result is a trustless, tamper-proof, system for global maritime data collection.

1 The Problem

AIS data underpins the modern maritime domain [1]. It enables vessel tracking, supports search and rescue operations, ensures navigational safety, and is used across industries for logistics, compliance, security, and finance. However, the current system for collecting and distributing AIS data is deeply flawed.

The AIS data ecosystem is controlled by a small number of centralized platforms, including Kpler, Orbcomm, and Spire, which aggregate data from commercial satellites, shore-based receivers, and a global network of volunteers. A significant portion of terrestrial AIS data is collected by hobbyists who operate receiver stations at their own expense. These contributors receive no financial compensation, and in many cases are only rewarded with access to premium platform tools if they meet strict uptime requirements.

Despite monetizing this data, centralized aggregators offer no way to validate whether the data is authentic or tampered with. AIS signals can be easily spoofed or manipulated, leading to the emergence of "ghost ships," illegal fishing vessels, and military decoys that transmit false locations. This undermines trust in the data and can have serious implications for national security, regulatory enforcement, and commercial decision-making.

Furthermore, coverage gaps persist, particularly in:

- Remote regions far from shipping lanes
- Developing nations with little infrastructure
- High-latitude zones affected by satellite congestion

Existing systems offer no meaningful mechanism to verify signal provenance, penalize bad actors, or incentivize coverage in underserved areas. Anyone could theoretically spoof AIS messages and submit fake data to naive platforms with no repercussions.

2 The MastChain Solution

MastChain is a decentralized protocol designed to reshape the global AIS data economy by rewarding contributors, ensuring data integrity, and expanding maritime visibility through trustless infrastructure. The network is built around three core innovations:

1. **Decentralized Data Collection**
   MastChain allows anyone to operate an AIS node, whether land-based, shipborne, buoy-mounted, or satellite-linked. Each node is cryptographically registered and tied to a unique on-chain identity. This open-access model increases coverage, especially in underserved regions where traditional AIS infrastructure is limited.

2. **On-Chain Validation & Fraud Resistance**
   Every AIS transmission is validated through a decentralized consensus mechanism. Nodes cross-verify timestamps, geolocations, and signal patterns to detect spoofed data. Majority consensus is used in dense areas, while low-density zones use trust scores and historical accuracy.

3. **Incentivized Network Growth**
   Once validated, contributors receive MAST tokens as compensation. These rewards are dynamically allocated based on:

   - Geographic scarcity (higher rewards in low-coverage zones)
   - Node reliability

   The DePIN model supports scalability far beyond what traditional terrestrial AIS networks have achieved.

2.1 Network Architecture

The MastChain Protocol is underpinned by a globally distributed mesh of AIS receiver nodes, each capable of independently capturing vessel broadcasts and securely submitting them for validation. These nodes can be deployed across diverse environments, including coastal shorelines, onboard commercial vessels, autonomous buoys, aircraft, and satellite platforms, allowing for continuous, decentralized maritime coverage across both high-traffic and remote regions of the ocean.

Each participating node is uniquely identified through a cryptographically registered on-chain address, enabling secure interaction with the protocol while ensuring accountability. Upon receiving AIS signals from nearby vessels [2], the node timestamps and

formats the data according to protocol standards. This raw AIS message is then transmitted to the MastChain network, where it enters a validation pipeline.

The MastChain validation process is built around a multi-layered, trustless consensus mechanism. In regions where AIS signals are received by several nodes concurrently, a majority consensus model is employed: independent receivers corroborate the location, time, and vessel identity information, ensuring that no single node can manipulate or fabricate data without detection. These submissions are cryptographically signed, and consensus is reached once a predetermined threshold of independently verified matches is achieved.

To protect the network against manipulation, each data submission is subject to a mandatory holding period before rewards are disbursed. During this time, additional network analysis occurs to detect inconsistencies, duplicated transmissions, or suspicious behavioral patterns. If anomalies are discovered, the submitting node may be penalized through partial slashing, withheld rewards, or in severe cases, permanent exclusion from the network.

At the core of the MastChain architecture is a hybrid storage model designed to balance scalability with verifiability. All data submitted to the network is divided into two components: on-chain metadata and off-chain raw AIS transmissions. The blockchain ledger maintains a tamper-proof record of validation hashes, timestamps, node identifiers, and verification outcomes. Meanwhile, the AIS messages themselves are stored off-chain in a scalable infrastructure optimized for maritime tracking applications. Each raw data file is cryptographically linked to its corresponding on-chain metadata, ensuring that any future retrieval or audit can confirm the integrity of the original submission.

2.2 Token Utility and Economics

The MastChain token serves as the native utility and incentive mechanism of the MastChain Network. It is designed not merely as a transactional medium, but as a structural pillar of the protocol's economic and validation model. The token coordinates behavior, enforces data integrity, and ensures that the individuals and organizations contributing to the network are fairly compensated for their efforts.

At its core, the MAST Token is used to reward contributors who submit valid AIS data. Each submission undergoes a multi-step validation process; only upon successful verification is a reward issued to the contributing node.

To ensure data quality and discourage manipulation on the network, all rewards are subject to a mandatory holding period before being released. During this time, submissions are monitored for discrepancies, such as repeated/duplicated signals, location inconsistencies, or time-based anomalies. If fraudulent behavior is detected, the submitting node may lose its reward, have its reputation score reduced, or be removed from the network altogether. This slashing mechanism is enforced on-chain, making it tamper-proof and transparent.

In addition to its reward function, the MastChain token also introduces an economic layer of accountability through its use as a collateral requirement. Nodes must maintain a small amount of MastChain in escrow in order to participate in the network. This creates a deterrent against low-quality data submission, since actors with skin in the game are incentivized to behave honestly. In the event of repeated violations, these collateral holdings may be partially or fully slashed.

Every AIS data submission also incurs a micro-fee — denominated in MAST — to offset validation costs and reduce network spam. While negligible for legitimate contributors, these fees create a structural cost for malicious actors attempting to flood the network with fabricated data. This fee is deducted from the final reward payout, streamlining the user experience while enforcing protocol discipline.

Unlike many blockchain-based systems that inflate continuously or rely on speculative value alone, MastChain incorporates a mechanism for real economic feedback. Data collected through the protocol is made available to institutional users, including logistics firms, insurers, port authorities, environmental monitors, and geopolitical analysts through API-based access. Revenue generated from these data services is used by the operating entity (Worldwide AIS Network ApS) to repurchase MAST tokens on the open market. These tokens may then be burned and removed from circulation.

By aligning contributor rewards with protocol usage and buyer demand, MastChain establishes a circular economy: contributors earn tokens for supplying validated data; buyers pay to access this data; and those payments are recycled into the system through buybacks.

3 Token Supply & Emissions Model

3.1 How the token supply is allocated

The MAST token is divided into several groups that support growth and stability:

Category	**%**	**MAST**
Node Rewards	65%	325,000,000
Dev Team Allocation	10%	50,000,000
Ecosystem Growth	10%	50,000,000
Exchange Liquidity	5%	25,000,000
Project Treasury	5%	25,000,000
Presale	5%	25,000,000

Table 1: Token supply allocation at genesis (Max supply: 500M MAST).

3.2 Emission Curve & Node Incentives

The primary way for tokens to enter circulation is via the Reward pool: stations providing data for the network receive a daily reward for their contribution, as long as certain

criterias are met.

3.3 Proof of Coverage

MastChain maps the world using H3 hexing at resolution five. A station earns from a hex on a given day if it provides the minimum valid AIS position reports inside that hex during the 24-hour reward window. The reward window is always from 00:00:00 UTC to 23:59:59 UTC.

The highlighted green hexes. Figure 1 shows hexes which are eligible for rewards. A hex is determined eligible for reward if valid AIS data is present within the hex for the minimum required message count.

A single station can earn from many hexes if it covers a wide area. Coverage is checked for each hex separately, so stations that cover multiple areas are rewarded fairly.

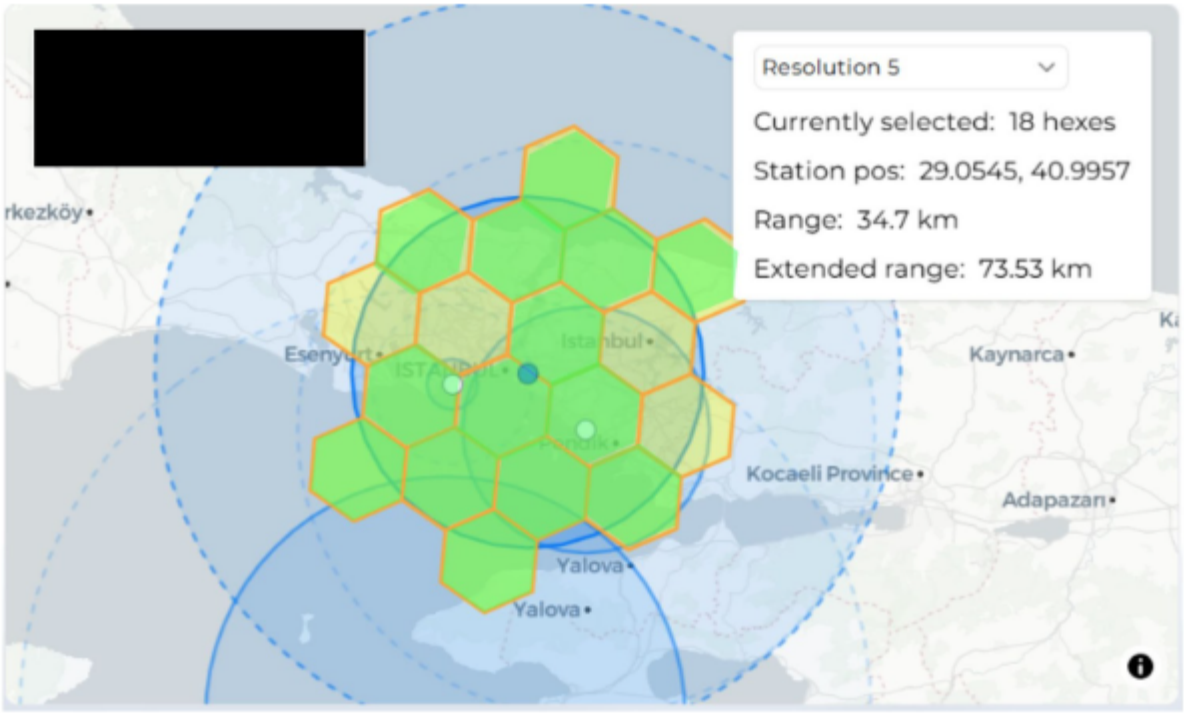

Figure 1: MastChain's Proof of Coverage hexing

A single station may cover multiple hexes. Coverage is evaluated independently per hex. Messages must satisfy basic validity checks such as timestamp sanity, valid MMSI formatting, and positional inclusion within the hex boundary.

MastChain encourages distribution of stations by limiting full payouts to two stations per hex. The rule for a hex with N eligible stations is

- If N is equal or less than 2, both stations that capture that hex both receive 100
- If N is greater than 2, then the station that captures data from that hex must share the rewards between the number of stations.

In the example shown in Figure 2, the hexes highlighted in red are where 3 stations overlap. In these hexes, the reward would be divided equally between the 3 stations. The hexes highlighted in green are eligible hexes where maximum 2 stations overlap. The red hexes highlighted are hexes that share more than 2 stations.

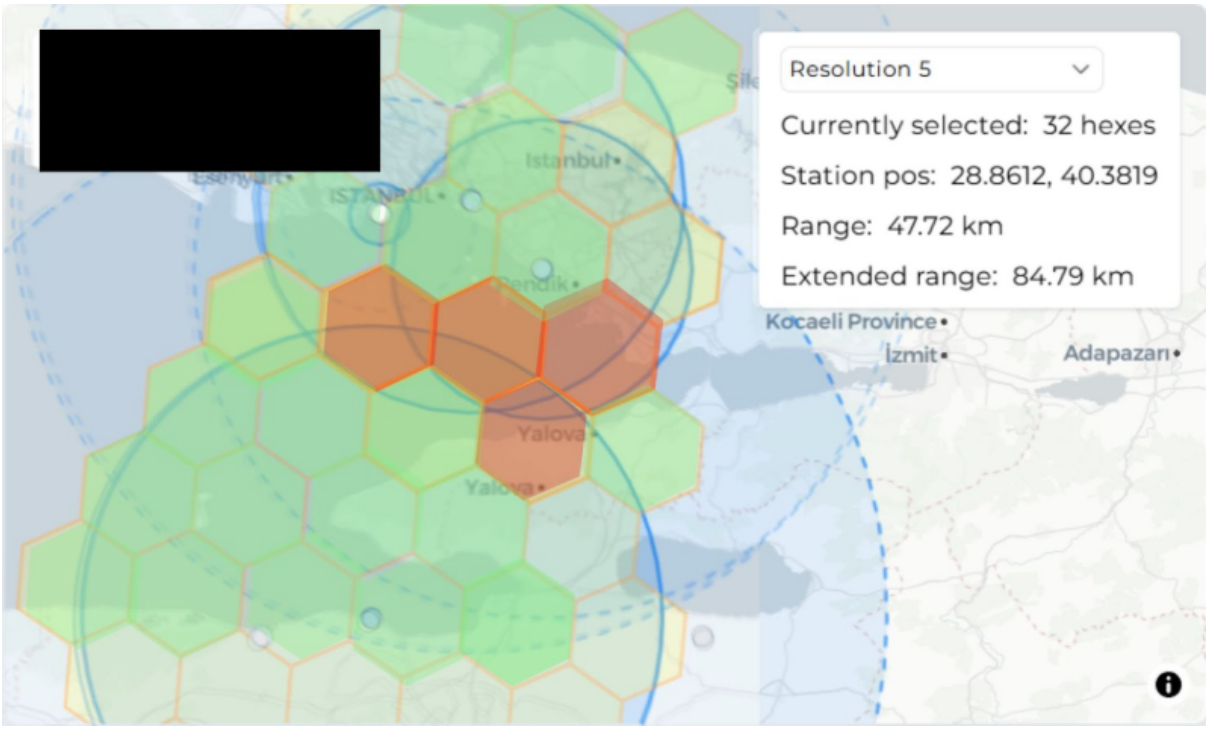

Figure 2: MastChain Proof of Coverage example of multiple stations covering the same hexes

This design encourages strategic node placement and decentralized expansion. For example, a node deployed on a remote coastline with few neighbors, high uptime, and a reliable stream of unique signals will receive a disproportionately high share of the daily rewards.

Conversely, nodes that operate in already saturated regions, submit redundant data, or go offline intermittently will earn far less, despite similar hardware or effort. This architecture creates a self-balancing network topology that evolves toward global efficiency without central coordination.

4 Base Rewards & Halving Cycle

4.1 Base Reward

The amount of MAST tokens received daily for a station covering a single hex, before bonuses and slashing, is called the "Base Reward".

To support the long term health of the system, the Base Reward rate slowly steps down over time. Every two years the daily reward amount is cut in half. This protects the value of rewards as the network grows. The 2 years base reward halving cycle can be found in Figure 3.

The Base Reward for the first year is fixed at **0.223 MAST**.

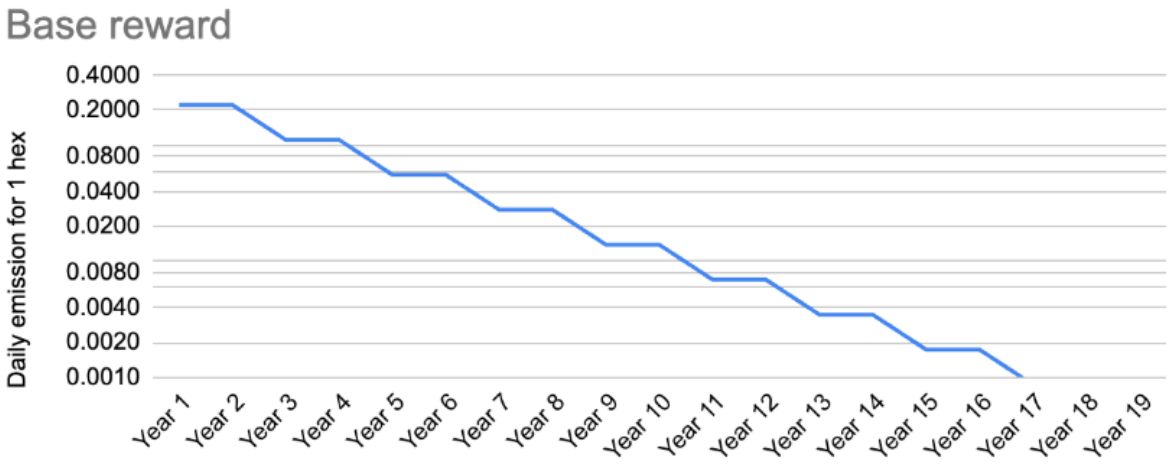

Figure 3: Base reward halving cycle

Each day the network releases a small and predictable amount of new tokens, proportional to the amount of hex tiles that have been capturing valid AIS data. This creates a steady reward system, incentivizing early adopters while also ensuring a negative inflation over time.

4.2 Uptime

For a station to earn rewards, it needs to show that it is reliably online.

Each device sends a small signed heartbeat once per minute. Missing heartbeats reduce the daily uptime score. A station needs at least eighty percent uptime to qualify for rewards.

Higher uptime earns bonus rewards: above 95% uptime the station get a bonus of +100% (compared to Base Reward) for all hex tiles. This makes stable installations more valuable to the network.

Note: all bonuses are additive against the base amount, they do not compound on each other.

4.3 Bonding

Each station keeps a small amount of MAST locked as a bond. This creates a basic safeguard against abuse. If a node in the network is seen to act maliciously, the staked MAST is slashed and those tokens are lost. Continual slashing may lead to removal from the network.

For a user to receive rewards from the network, their account must first reach a minimum bond amount. Once the bond threshold is reached, the user can withdraw the rewards over the bond threshold to their own wallet.

If a station behaves honestly, the bonded amount can be withdrawn from the network, however a 28 day period is applied to the withdrawal.

4.4 Bonuses & special incentives

Bonuses allow the team to direct capital where it creates the most value. These bonuses are additive on top of the base reward for a hex and are computed against the base amount, not against each other. There are two categories.

- **Referral bonuses:** Referral bonuses can be granted to a contributor who brings in other active stations. The referral percentage is set per account and capped at 50% of the base reward.
- **Area-of-interest bonuses:** Area of interest bonuses can be attached to designated hexes and can be as high as 200% of the base reward for those hexes. These bonuses

are time bound and are intended to seed critical corridors, chokepoints, or regions with sparse data.

4.5 How the token captures value

MastChain earns revenue by selling AIS data to enterprise customers. These buyers pay in fiat currency.

A share of this revenue is used to buy MAST tokens on the open market. The tokens purchased are permanently removed from circulation. This creates steady long term scarcity and links the value of the token to the success of the data business. Burn address and amounts are visible on the blockchain.

5 Network participation

5.1 Hardware Requirements

MastChain is designed to be inclusive and accessible, enabling participation from individuals, vessel operators, and communities around the world, including in developing regions. Any standard AIS reception setup that meets basic performance criteria can be used to operate a node.

To maintain data quality, each node must meet the following minimum requirements:

- A VHF AIS-capable receiver (e.g., SDR with support for AIS channels or dedicated AIS hardware [5])
- GPS-based timestamping, or an NTP-synchronized system clock
- Stable internet connectivity for data submission
- Consistent uptime and accurate geolocation reporting

Each hardware node is cryptographically linked to a single on-chain wallet. This ensures a one-to-one relationship between physical equipment and digital identity, enabling transparent reward attribution, behavior tracking, and fraud prevention. Multiple wallets cannot share the same hardware, and each wallet must operate independently validated equipment.

MastChain does not prescribe specific device models, but nodes must meet baseline requirements for signal fidelity, clock accuracy, and location consistency to qualify for rewards. This introduces a modest cost barrier, deterring spam or dishonest activity while remaining within reach for committed contributors. In the future, MastChain may introduce a standardised hardware solution for network participation.

6 Fraud Detection & Data Integrity

6.1 Validation Mechanics

MastChain treats every AIS message as a claim that must be tested. Contributors may be honest, careless, or actively malicious, so the protocol does not assume trust at any stage. Instead, each submission is examined through a series of independent validation layers. These layers are structured to detect different types of manipulation and gradually build certainty about data integrity.

The validation system has two goals:

- To reward fresh and accurate AIS signals.
- To filter, interrogate, and penalise fabricated or manipulated data

This approach allows MastChain to operate reliably even in low-density regions and during early network roll out, when peer coverage is sparse.

6.2 Integrity by Design

MastChain is built for a world in which no node can be trusted, only the data they provide. This adversarial mindset is fundamental to the protocol's architecture. From economic slashing to physics-based validation, MastChain is engineered to resist manipulation at every layer.

The protocol's design assumes that some participants will attempt to game the system for profit. It accounts for actors who may spoof messages, replicate data, fabricate GPS positions, or attempt to flood the network with low-value submissions. Each of these threats is met with a multi-layered mitigation strategy.

Peer agreement mechanisms prevent isolated nodes from fabricating consensus. Collusion scoring detects duplicated message sets across long distances. Signal timing validation uses the speed of light as a hard constraint on spoofed timestamps. Node motion modeling checks for improbable geographic jumps.

MastChain is also economically hardened. By requiring all contributors to lock tokens for a defined period before earning rewards, and by slashing that collateral if fraud is detected, the protocol makes dishonest behavior unprofitable at scale. The cost of deploying and maintaining hundreds of spoofing nodes outweighs the potential rewards, especially in a network designed to downrank duplicate data and favor geographic diversity.

While no system can eliminate all edge cases, MastChain is designed to detect inconsistency at scale. By requiring geographic, temporal, and behavioral consistency across multiple independent nodes, the protocol makes manipulation increasingly difficult to sustain.

7 Data Storage & Integrity Architecture

MastChain employs a hybrid storage model to ensure scalability without compromising validity. Given the high volume and frequency of AIS broadcasts, storing raw data entirely on-chain would be inefficient and cost-prohibitive. Instead, MastChain separates each data submission into two layers:

- Off-Chain Payloads: Raw AIS messages, including MMSI, timestamp, latitude/longitude, SOG, and COG etc. are stored off-chain in a decentralized but scalable data infrastructure. This allows the network to handle millions of daily submissions while keeping storage costs and bandwidth requirements manageable.
- On-Chain Metadata: For every submission, a cryptographic hash of the AIS message, the submitting node's ID, timestamp, validation results, and reward amount are committed on-chain. This creates a tamper-proof audit trail that links each AIS message to its origin and validation history, without exposing sensitive or bulky data directly on-chain.

Each off-chain file is cryptographically bound to its on-chain reference, ensuring the two cannot diverge. If a message is altered or deleted off-chain, it will fail integrity checks against its on-chain hash, making tampering immediately detectable.

This model ensures that:

- Nodes cannot manipulate stored data after submission.
- Buyers and auditors can verify provenance without trusting the submitter.
- Storage infrastructure remains scalable across global deployments.

8 Data Access & Commercial Integration

MastChain goal is not just to operate as a decentralized network, but to become a trusted commercial-grade data layer built for real-world use. Once AIS data is validated through the protocol's multi-layered consensus engine, it is made available through secure and structured delivery channels:

- API Access: Real-time and historical AIS data can be accessed by enterprise clients through tiered subscription APIs, supporting applications across insurance, logistics, environmental monitoring, and port operations.
- Bulk Licensing: Financial, Academic and analytics providers can license complete datasets, backed by cryptographic proofs of origin and validation
- Custom Intelligence Streams: Users with advanced needs, such as compliance, risk scoring, or illicit behavior detection, can subscribe to filtered data feeds tailored by geography, vessel type, or behavioral profile.

All data products are priced in fiat to ensure seamless enterprise adoption. Revenues are managed by Worldwide AIS Network ApS and used to strengthen the token economy via market buybacks.

9 Conclusion

MastChain redefines the foundations of global maritime intelligence. By decentralizing AIS data collection and anchoring validation in cryptographic truth rather than institutional trust, it introduces a radically more resilient, transparent, and equitable model for how maritime data is captured, verified, and monetized.

For too long, AIS data has been harvested from unpaid contributors, processed by black-box platforms, and sold without any accountability to those who made it possible. MastChain fixes this at every layer: contributors are rewarded, data is validated through peer consensus and physics-based constraints, and the economic loop is closed through real-world demand and token scarcity.

The implications extend far beyond shipping lanes.

- Supply Chain Optimization: Logistics companies can access verified vessel positions in real time, improving ETAs, port scheduling, and multimodal coordination.
- Insurance & Risk Analytics: Underwriters and actuaries gain access to validated movement patterns, incident detection, and compliance data to improve modeling and reduce exposure.
- Commodities & Trade Finance: Traders, banks, and analysts can monitor cargo flows, detect anomalies in global movement, and verify delivery timing, enabling more accurate pricing, counterparty verification, and risk scoring.
- Environmental Monitoring: NGOs and regulators can track emissions, identify illegal fishing, and monitor vessel behavior in ecologically sensitive zones with confidence.

MastChain offers a universal, permissionless data infrastructure that can serve every one of these needs and do so with mathematical integrity. It provides not only a new way to earn value from AIS data, but a new standard for proving it.

As adoption grows, MastChain is positioned to become the backbone of a new maritime data economy, one where trust is not granted but computed, where every contributor has economic agency, and where the value of information flows back to its origin.

10 Future Work & Outlook

MastChain represents a foundational shift in how maritime data is captured, verified, and distributed, but it is only the beginning. As the protocol gains adoption and the global node network expands, future development will focus on deepening functionality, expanding accessibility, and unlocking new layers of economic utility.

On the hardware side, dedicated receiver kits may be introduced to streamline node deployment, particularly in regions with low coverage or limited technical infrastructure. These kits would reduce onboarding friction for contributors and help accelerate global distribution. Future iterations of the protocol may also support enhanced node types, such as mobile shipborne relays, high-fidelity satellite receivers, or trusted third-party validators.

The MastChain token economy will continue to evolve in tandem with network maturity. Additional contributor roles may be introduced, such as curators, data reviewers, or regional stewards, expanding participation beyond raw signal capture. Optional staking mechanisms or bonded roles could enable more sophisticated governance over regional network growth, while preserving MastChain's trustless data model.

On the commercial side, MastChain's verified AIS dataset offers a foundation for advanced maritime analytics and predictive systems. Financial markets and commodities traders can use ship movement data to infer cargo flows, market shocks, or trade imbalances. Port operators can optimize berth allocation based on real-time vessel behavior. Environmental agencies can monitor emissions, illegal fishing, or marine protected zones with greater granularity. Security and defense entities can use MastChain data to identify ghost fleets, decoys, or anomalous patterns with confidence that the underlying signals have been independently validated.

Over time, MastChain may also become a launchpad for derivative data products, including emissions profiles, vessel risk scores, route congestion indices, or even tokenized access rights to regional traffic zones. As the network grows in utility, so too will the opportunity for new business models, applications, and participants.

Ultimately, MastChain is designed not as a single-use protocol, but as a composable infrastructure layer, one that can underpin the next generation of maritime logistics, trade intelligence, and decentralized data markets. Its trajectory will be shaped by the communities that build atop it.

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A Glossary of Terms

AIS: Maritime tracking system that broadcasts vessel identity, position, speed and course.
Area-of-Interest Bonus: Temporary boost in rewards for specific geographic regions where more AIS coverage is needed, such as chokepoints or sparse areas.
Bond Threshold: The minimum number of tokens a contributor must lock in order to start earning rewards. It acts as a security deposit to discourage dishonest submissions.
DePIN: Decentralized Physical Infrastructure Network - blockchain concept where physical hardware, such as AIS receivers, forms a real-world network and earns tokens for its contribution.
MMSI: Maritime Mobile Service Identity, a nine-digit vessel identifier.
SOG: Speed Over Ground.
COG: Course Over Ground.
Token Burn: Permanent removal of tokens from circulation.
Slashing: Penalty mechanism for dishonest nodes.
API: Interface for programmatic data access.