

# Industrial Digital Passport Protocol

Blockchain for Complete Industrial Traceability

Technical Presentation →

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# The Problem of Industrial Traceability

## Current Industry Challenges

- **Complex Chains:** Products involve 200+ suppliers across 15+ countries
- **Fragmented Data:** Information scattered across incompatible systems
- **Lack of Verification:** No cryptographic proof of authenticity
- **Lost Records:** 30% of industrial equipment lacks complete history
- **Manual Compliance:** Costly and error-prone process

## The Equipment "Black Box"

When you buy industrial equipment today:

- **✗ Limited documentation** or lost over time
- **✗ Maintenance history** incomplete or non-existent
- **✗ Component origin** unknown
- **✗ Disputed warranties** without clear evidence
- **✗ Complex compliance** for auditors




**Result:** Inefficiency, high costs, regulatory risks

# Market Pressures: Why Act Now?

## Regulatory Mandates

- **EU Digital Product Passport:** Mandatory from 2027
- **LGPD in Brazil:** Data compliance
- **Global ESG standards:** Supply chain transparency
- **Transparency laws:** Mandatory traceability

## Market Demands

-  **B2B Customers:** Require complete history before purchase
-  **Insurers:** Offer discounts for traceable equipment
-  **Consumers:** Value transparency and sustainability

## Business Opportunities

### **Value Creation**

- **Premium pricing:** Products with history sell 15-25% above
- **Cost reduction:** 40% fewer warranty disputes
- **New models:** Product-as-a-service based on real data

### **Competitive Advantage**

- **First-mover advantage:** Pioneering transparency
- **Brand differentiation:** Differentiation through traceability
- **Customer trust:** Trust through evidence

# The Solution: Digital Passport Protocol

## Experience Transformation

### Before: "Black Box"

- Lost paper documentation
- Fragmented history across multiple systems
- Costly manual verification
- Frequent authenticity disputes

### After: "Total Transparency"

- 🔍 **QR Code** → Complete history on blockchain
- 📱 **Mobile app** → Instant access for technicians
- 🤖 **Automation** → Automatic compliance and auditing
- 💡 **Insights** → Predictive analytics for maintenance

## Blockchain Architecture

### 🏛️ Neutral Infrastructure

- **Arbitrum Network**: Reliable public network
- **EAS Protocol**: Global standard for attestations
- **Multi-manufacturer**: WEG + others can use

### 🔒 Security and Control

- **Role-based**: Each stakeholder can only register their scope
- **Immutability**: Data can never be altered
- **Verifiability**: Anyone can confirm authenticity

### 📈 Scalability

- **Low cost**: ~\$0.01 per transaction
- **Performance**: 4,000+ TPS
- **Global**: Works in any country

# Blockchain and Smart Contracts - Fundamentals

## What is Blockchain?

A **decentralized network** of computers that maintains an **immutable** and **transparent** ledger.

### Key Characteristics:

- 📖 **Immutability:** Records cannot be changed
- 🔍 **Transparency:** Everyone can verify the data
- 🛡️ **Security:** Cryptography ensures integrity
- 📡 **Decentralization:** No single point of failure

## Smart Contracts

**Digital contracts** that execute automatically when conditions are met.

### For Industrial Traceability:

- ⚖️ **Business Rules:** Who can create what type of record
- 🗝️ **Access Control:** Role-based permissions
- ✅ **Automatic Verification:** Data validation at creation
- 📊 **Audit:** Complete trail of all operations

# Public vs Permissioned Networks

## Public Networks

(Ethereum, Arbitrum)

### ✓ Advantages:

- **Neutrality:** No company controls
- **Credibility:** Globally guaranteed immutability
- **Interoperability:** Open standard for everyone
- **Censorship resistance:** Data always accessible
- **Network effects:** Greater adoption = greater value

### ✗ Disadvantages:

- **Variable cost:** Fees may fluctuate
- **Total transparency:** Public data (mitigable)
- **Limited performance:** Fixed throughput

## Permissioned Networks

(Hyperledger, R3 Corda)

### ✓ Advantages:

- **Total control:** Company decides rules
- **Complete privacy:** Non-public data
- **Custom performance:** Specific optimization
- **Predictable costs:** Own infrastructure

### ✗ Disadvantages:

- **Centralization:** Control by one entity
- **Limited credibility:** Data can be altered
- **Vendor lock-in:** Supplier dependency
- **Limited interoperability:** Integration difficulty

# Our Choice: Arbitrum (Public Network)

## Why Public Network?

For **industrial traceability**, supply chain stakeholders need to **trust each other**:

- 🏭 **Manufacturers** don't control data alone
- 🚚 **Carriers** can verify authenticity
- 🏢 **Distributors** trust the history
- 👤 **End customers** have transparency guarantee
- 🏛️ **Auditors** can verify independently

**Neutrality is essential** for multi-stakeholder trust

## Why Arbitrum Specifically?

Arbitrum Layer 2 over Ethereum:

- 💰 **Low Cost**: ~\$0.01 per transaction vs \$0.50 on Ethereum
- ⚡ **Performance**: 4,000+ TPS vs 15 TPS on Ethereum
- 🔒 **Inherited Security**: Same security as Ethereum
- 🌐 **Interoperability**: Compatible with entire Ethereum ecosystem
- 📈 **Scalability**: Supports millions of industrial products

### Best of both worlds:

Public network security and credibility + private network performance and cost

# How Blockchain Solves Our Problem

## Total Traceability

### Traditional System

- Data scattered across different systems
- Lost paper trails
- Incomplete history
- Difficult to verify

### Blockchain Solution

- **Single source of truth:** All data in one place
- **Immutable history:** History can never be lost
- **Cryptographic proof:** Mathematical verification of authenticity
- **Real-time access:** Available 24/7 globally

## Verifiable Trust

### Traditional Trust

- Based on reputation
- Depends on intermediaries
- Subject to fraud
- Expensive to verify

### Cryptographic Trust

- **Digital signatures:** Each entry is digitally signed
- **Multi-party validation:** Multiple actors confirm
- **Tamper-evident:** Any alteration is detectable
- **No intermediaries:** Elimination of third parties

## Interoperability

### Traditional Silos

- Proprietary formats
- Different APIs
- Costly integration
- Technology lock-in

### Open Standards

- **EAS Protocol:** Open global standard
- **Universal format:** Same format for everyone
- **Single API:** Standardized interface
- **Future-proof:** Evolves with the ecosystem



# Public vs Permissioned: Our Choice

## Technical Comparison

Aspect	Public Network	Permissioned Network
<b>Control</b>	Decentralized	Centralized
<b>Access</b>	Anybody	Only invited
<b>Verification</b>	Independent	Depends on consortium
<b>Cost</b>	Variable	Fixed/High
<b>Transparency</b>	Total	Limited
<b>Interop</b>	Global	Restricted

## Why We Chose Public Network?

### ✅ Benefits of Public Network

- **Neutrality:** No company controls
- **Independent verification:** Auditors can confirm
- **Global interoperability:** Works with any system
- **Censorship resistance:** Data always accessible
- **Network effects:** More value as more adoption

### ⚠️ Limitations of Private Networks

- **Vendor lock-in:** Dependency on one supplier
- **Lower trust:** "Self-signed certificates"
- **Limited scalability:** Only for consortium
- **Higher TCO:** Own infrastructure costly

# Ethereum Attestation Service (EAS)

## What is EAS?

**Decentralized protocol** on Arbitrum to create verifiable **attestations** about anything.

### Key Characteristics:

- 🌐 **Universal Standard:** Open protocol used globally
- 🗑️ **Immutable:** Attestations cannot be changed
- ✅ **Verifiable:** Anyone can confirm authenticity
- 🏗️ **Flexible:** Supports any type of structured data

## Why EAS for Industry?

- 📄 **Structured Events:** Each type of industrial event has specific format
- 👥 **Multi-Stakeholder:** Different participants create different types of records
- 🔍 **Audit:** Complete trail of who did what and when
- 🌐 **Interoperability:** Standard that other companies can use

# Schemas: Defining Event Types

## What are Schemas?

**Structured templates** that define what type of information can be recorded in each attestation.

Example - Product Schema:

```
{  
  productModel: string,  
  serialNumber: string,  
  timestamp: number,  
  composition: string,  
  suppliers: string[],  
  manufacturingLocation: string,  
  qualityStandards: string  
}
```

## WEG Defined Schemas

**5 schemas** cover the complete lifecycle:

1. 🏭 **WEG\_PRODUCT\_INIT**: Product creation
2. 🚚 **WEG\_TRANSPORT\_EVENT**: Transport events
3. 📁 **WEG\_OWNERSHIP\_TRANSFER**: Ownership changes
4. 🛠️ **WEG\_MAINTENANCE\_EVENT**: Maintenance and repairs
5. ♻️ **WEG\_END\_OF\_LIFE**: End of life and recycling





**Each schema = Specific type of industrial event**

# Access Control: Roles and Resolvers

## Resolvers: Smart Validation

**Smart contracts** that validate **who can create** each type of attestation **before** it's recorded on blockchain.





## Features:

-  **Permission Validation:** Only authorized can create
-  **Business Rules:** Custom logic per schema
-  **Security:** Prevents invalid or malicious records
-  **Audit:** Log of all creation attempts

## Role System

**Granular control** based on responsibilities in industrial chain:

## Main Roles:

-  **Manufacturer:** Product creation and all schemas
-  **Logistics:** Only transport events
-  **Technician:** Only maintenance events
-  **End Customer:** Only query (no creation)





**Each role has specific permissions**  
for different types of industrial  
events

# Digital Signatures: Security and Non-Repudiation

## EIP-712: Structured Signatures





**Ethereum standard** for secure digital signatures of structured data.

For Industrial Events:

-  **Cryptographic Authentication:** Proves who created the record
-  **Non-repudiation:** Creator cannot deny having created
-  **Integrity:** Data cannot be modified without detection
-  **Legal Value:** Digital signatures recognized by law

## Signature Process

### Creation Flow:

1.  **Event Data:** Technician fills event information
2.  **Digital Signature:** EIP-712 signature with private key
3.  **Blockchain Submission:** Attestation created on Arbitrum
4.  **Verification:** Anyone can verify signature authenticity

### Legal Guarantee:

Each industrial event is **digitally signed** by its creator, providing **legal proof** of authenticity.

# Digital Passport Architecture

## Main Components



### Base Infrastructure (Shared)

- **PassportRegistry**: Indexing of all products
- **DigitalPassportFactory**: Controlled passport creation
- **Multi-manufacturer architecture**: WEG + other manufacturers







### WEG Manager (Specific)

- **ManufacturerManager**: Reusable abstract contract
- **WEGManager**: WEG-specific implementation
- **Role system**: Stakeholders with granular permissions

## Digital Passport Contract

One contract per product that stores:

-  **Basic Information**: Product ID, manufacturer, creation date
-  **Attestation List**: References to all EAS events
-  **Query Functions**: History by schema, by period
-  **Event Log**: Chronological record of all operations

**Each product = One unique passport**

**Note:** Access control is handled by **WEGManager** and **Resolver**

# ManufacturerManager: Reusable Pattern

## Abstract Contract

```
abstract contract ManufacturerManager {
    // Manufacturer information
    address public manufacturer;
    string public manufacturerName;
    string public manufacturerCountry;

    // Permission system
    mapping(string => RoleInfo) public roles;
    mapping(address => StakeholderInfo) stakeholders;
    mapping(string => bytes32) registeredSchemas;

    // Abstract functions (each manufacturer implements)
    function _initializeSchemas() internal virtual;
    function _createRoles() internal virtual;

    // Standardized functions (all use the same)
    function createRole(name, description, schemas);
    function addStakeholder(address, name, role);
    function hasPermission(stakeholder, schema) bool;
    function createSchema(name, schemaDefinition) returns (bytes32);
}
```

## WEGManager: Specific Implementation

```
contract WEGManager is ManufacturerManager {

    constructor(factory, eas, registry, wegWallet) {
        manufacturer = wegWallet;
        manufacturerName = "WEG S.A.";
        manufacturerCountry = "Brasil";








        _initializeSchemas(); // 5 initial WEG schemas
        _createRoles();       // 7 WEG roles
    }

    // WEG defines its own initial schemas
    function _initializeSchemas() internal override {
        WEG_PRODUCT_INIT_SCHEMA =
            createSchema("product_init", productInitDefinition);
        WEG_TRANSPORT_EVENT_SCHEMA =
            createSchema("transport_event", transportDefinition);
        // ... other 3 initial schemas
    }

    // WEG can add new schemas anytime
    function addNewSchema(string name, string definition)
        public onlyManufacturer returns (bytes32) {
```

# WEG Role System

## Defined Roles

Role	Stakeholder	Allowed Schemas
 <b>manufacturer</b>	WEG S.A.	All (5 schemas)
 <b>maintenance_technician</b>	Authorized technicians	MAINTENANCE_EVENT only
 <b>logistics_provider</b>	Transport companies	TRANSPORT_EVENT only
 <b>distributor</b>	Product distributors	OWNERSHIP_TRANSFER only
 <b>end_customer</b>	Final customers	Query only (no creation)
 <b>recycling_facility</b>	Recycling centers	END_OF_LIFE only
 <b>auditor</b>	External auditors	Query only (all data)

## System Advantages

### Granular Permissions

- Each stakeholder can only register events within their responsibility
- Technicians cannot change ownership
- Carriers cannot perform maintenance

### Scalability

- New stakeholders only need to be assigned to existing roles
- Role changes affect all stakeholders automatically

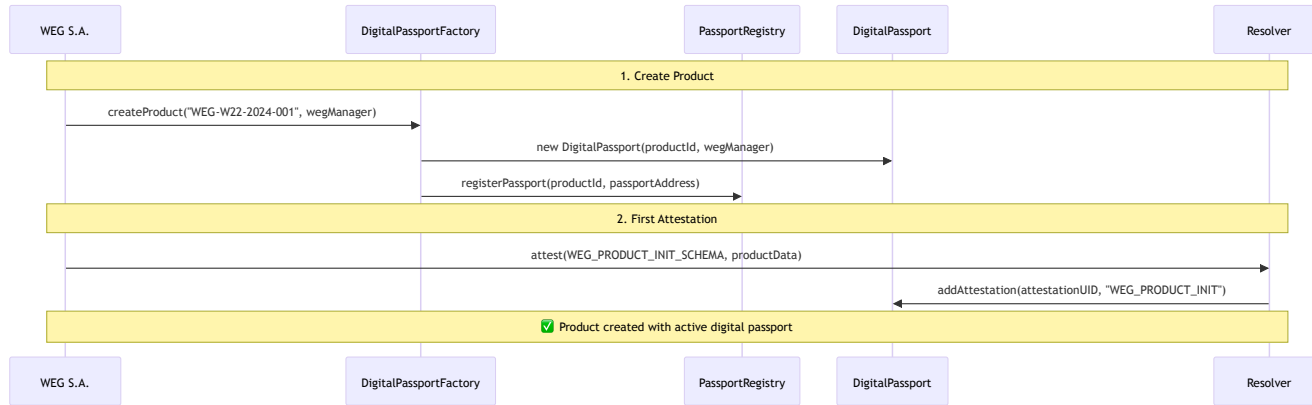
### Security

- Automatic validation before creating any record
- Audit trail of who did what

**Note:** Each stakeholder can only create the type of event they are authorized for



# Product Creation Flow



**Result:** Product with unique digital identity on blockchain, ready to receive supply chain events

# Hierarchical Traceability

## Multi-Level Structure

### **Main Product**

- WEG W22 100HP Motor
- Main digital passport
- Reference to all components

### **Components**

- Stator, Rotor, Housing, Bearings
- Each with its own passport
- Linked to main product

### **Sub-components**

- Copper (Codelco), Steel (Gerdau), Magnets, Insulation
- Traceability to raw materials
- Origin certification

## Hierarchy Benefits

### **Smart Recycling**

- Exact knowledge of materials
- 95% of recoverable materials identified
- Automated sustainable destination

### **Complete Audit**

- Trail from raw materials to final product
- Conflict-free materials certification
- Automated regulatory compliance

### **Added Value**

- Products with history sell at premium prices
- Reduced insurance costs
- Predictive maintenance based on real data

# Use Case Example: WEG W22 100HP Motor

## Real Product

### WEG W22 100HP Motor

- **Product ID:** WEG-W22-2025-001
- **Model:** Three-Phase Electric Motor
- **Application:** Integration in Thyssenkrupp elevator
- **Lifecycle:** 2025-2040 (15 years)

### Supply Chain Stakeholders

-  **WEG S.A.** (Manufacturer)
-  **WEG Export Brasil** (Export)
-  **Thyssenkrupp** (Integrator)
-  **Maersk Line** (Logistics)
-  **Construções Brasil** (Distributor)
-  **Condominium** (End customer)
-  **João Silva** (Technician)
-  **GreenRecycle** (Recycling)

## Geographic Journey

### Brazil → Germany → Brazil

**Manufacturing:** Jaraguá do Sul, SC

↓ **National transport**

**Export:** Port of Itajaí, SC

↓ **Maritime transport**

**Arrival:** Port of Hamburg, DE

↓ **Elevator integration (Germany)**

**Final Product:** Complete elevator in Düsseldorf, DE

↓ **Maritime transport back**

**Arrival in Brazil:** Port of Santos, SP

↓ **National transport**

**Final Destination:** São Paulo, SP

**Each step = Verifiable attestation**

# Complete Lifecycle: 15 Years of Records

## ⚡ Phase 1: Production (2025)

### 🏭 Jan 2025 - WEG Jaraguá do Sul

- Product Init: Product creation
- Composition: 95% recyclable materials
- Quality tests: Approved

### 📦 Feb 2025 - WEG Export Brasil

- Transport Event: Factory departure
- Destination: Port of Itajaí
- Conditions: Temperature controlled

### 🚢 Mar 2025 - Maersk Line

- Transport Event: International shipment
- Ship: Maersk Sealand
- Destination: Hamburg, Germany

## 🏗️ Phase 2: Integration (2025)

### 🏢 Apr 2025 - Thyssenkrupp Germany

- Ownership Transfer: Motor received
- Integration in ThyssenOne elevator
- Complete system tests

### 📦 May 2025 - Thyssenkrupp

- Final Product: Complete elevator
- Transport Event: Shipment back to Brazil
- Ship: Maersk to Santos, SP

### 🏢 Jun 2025 - Construções Brasil

- Ownership Transfer: Elevator received
- Transport Event: To installation in SP

### 👤 Jul 2025 - Condominium

- Ownership Transfer: End customer
- Start of commercial operation

## 🔧 Phase 3: Operation (2025-2040)

### Years 1-5: Warranty

- Preventive maintenance
- Software updates
- Performance monitoring

### Years 5-10: Normal operation

- Occasional corrective maintenance
- Minor component replacement
- Efficiency optimizations

### Years 10-15: Modernization

- Technology retrofits
- Lifetime extension
- Replacement preparation

### Year 15: End of Life

- ♻️ Recycling: 95% materials recovered

# Registered Attestations: Complete Trail

## Blockchain History of Motor WEG-W22-2025-001

Date	Stakeholder	Schema	Event	Location	Details
<b>Jan/25</b>	WEG S.A.	PRODUCT_INIT	Creation	Jaraguá do Sul	100HP motor created, tested, approved
<b>Feb/25</b>	WEG Export	TRANSPORT_EVENT	Transport	SC → Itajaí	National transport, temp. controlled
<b>Mar/25</b>	Maersk Line	TRANSPORT_EVENT	Shipment	Itajaí → Hamburg	Ship Maersk Sealand, container 234
<b>Apr/25</b>	Thyssenkrupp	OWNERSHIP_TRANSFER	Receipt	Hamburg, DE	Motor received for integration
<b>May/25</b>	Thyssenkrupp	TRANSPORT_EVENT	Integration	Düsseldorf, DE	Complete elevator assembled
<b>May/25</b>	Thyssenkrupp	TRANSPORT_EVENT	Return	Hamburg → Santos	Elevator shipped to Brazil
<b>Jun/25</b>	Construções Brasil	OWNERSHIP_TRANSFER	Receipt	Santos, SP	Elevator arrived at distributor
<b>Jul/25</b>	Condominium	OWNERSHIP_TRANSFER	Purchase	São Paulo	End customer, operation start
<b>Jan/26</b>	João Silva	MAINTENANCE_EVENT	Preventive	São Paulo	Lubrication, general check
<b>Jul/26</b>	João Silva	MAINTENANCE_EVENT	Preventive	São Paulo	Filter change, calibration
...	...	MAINTENANCE_EVENT	...	...	<b>180+ events</b> over 15 years
<b>Dec/40</b>	GreenRecycle	END_OF_LIFE	Recycling	São Paulo	95% materials recovered

**Result: 200+ verifiable attestations** covering **15 years** of history

# Real Benefits from This Example

## For WEG

### Performance Data

- Real field usage history
- Feedback for product improvement
- Quality evidence for marketing

### Brand Protection

- Counterfeit products easily identified
- Complete anti-fraud traceability
- Shared responsibility in the chain

### New Business Models

- Product-as-a-Service (PaaS) viable
- Warranties based on real usage
- Monetizable predictive maintenance

## For Stakeholders

### Thyssenkrupp

- Trust in component quality
- History for extended warranties
- Competitive differentiation

### End Customer

- Total product transparency
- Preserved resale value
- Optimized maintenance

### Industry

- Efficient recycling (95% recovery)
- Automatic regulatory compliance
- Proven sustainability

# Digital Passport in Action

QR Code on Product

Stakeholder Benefits

# Questions & Discussion

We're open to discussing:

## Technical Aspects

- Blockchain solution scalability
- Integration with existing ERP systems
- Operational and transaction costs
- Security and access control
- Performance in high-volume scenarios

## Industrial Implementation

- Specific use cases for different industries
- ROI and business models
- Regulatory compliance
- Stakeholder onboarding process

## Architecture and Ecosystem

- Interoperability between manufacturers
- Expansion to other countries/regulations
- Integration with IoT and sensors
- Data analysis and insights

## Sustainability and ESG

- Environmental impact of the solution
- Traceability of sustainable materials
- Compliance with green regulations
- Circular economy metrics

## Next Steps

Contact for technical discussions:

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