FINAL REPORT AUGUST 2021

PROJECT ITOPP

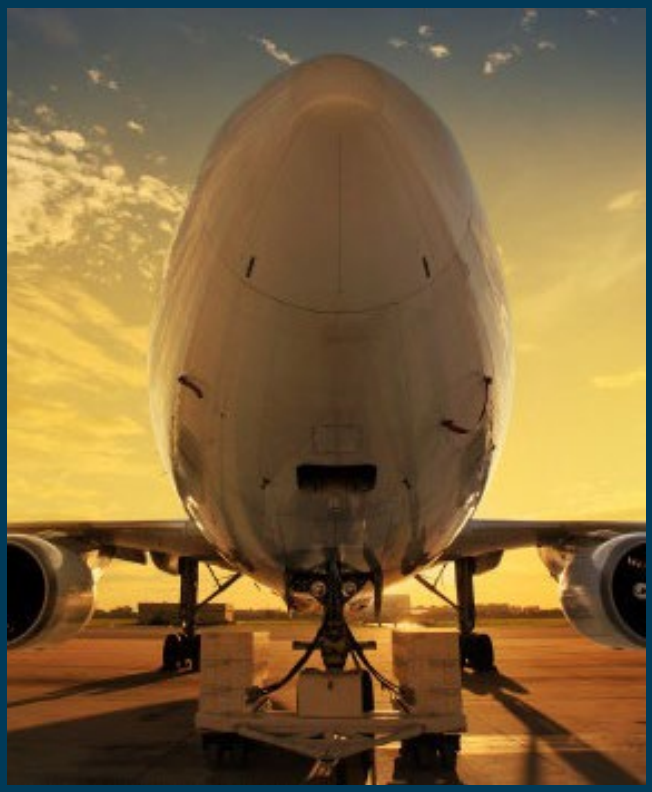
IMPROVED TRACEABILITY OF PARTS AND PRODUCTS

TKI DINALOG
Dutch Institute for Advanced Logistics

SUMMARY

The aim of the IToPP project was to develop a digital platform for enabling traceability in regulated industries. The developed platform is highly innovative by using Blockchain technology to support traceability of parts and products multiple steps upstream and downstream in the supply chain. The platform enables back-to-birth trace, trusted trace information, dispute management and payment duration. It also enables firms to integrate with existing companywide information systems such as Enterprise Resource Management Systems (ERP).

As the project aims to improve the traceability in high-tech, medical and aerospace supply chains, first step was to understand the traceability process. The most formal traceability process among these, aerospace sector, was investigated and software design requirements were defined. These requirements were discussed with subject matter experts and further refined. In parallel the blockchain technologies were investigated and appropriate solution was selected. Considering the nature of process consortium blockchain chains where the actors are clearly defined selected as a solution. The supply chain process steps are coded into blockchain as transactions of contract.



It is observed that blockchain coupled with other tracking technologies such as IoT and QR, provides a solution for traceability of parts and products. Blockchain contributes in different ways to traceability. First, the ownership of the parts and data is clearly established with the blockchain increasing efficiency of the process. Second the owners have record and share the transactions as needed by the other members. Third the blockchain can be coupled with ERP and/or enterprise systems, so that interorganizational and intraorganizational functions are clearly identified. Fourth, other processes such dispute management and payment is streamlined and automated with a blockchain. These improvements are introduced into the prototype developed with collaboration of implementation partner.

During the blockchain development, it is also observed that several aspects should be considered during any blockchain development. The immutability and integrity benefit is maximized when all the actors participate in the blockchain from suppliers to end users. Each actor or group of actors are represented as peers in the blockchain. Actors should also develop generic or specific interfaces to blockchain which they may include additional functionality for privacy, filtering or referencing. In the project a traceability API was developed for this purpose. Finally, the blockchain data should be presented to the user in a meaningful way contextually. For this purpose, several interfaces were developed for listing of parts, displaying trace history and referencing part via QR. The GUI forms provide the interfaces for calling the transactions.

The feasibility of blockchain adaptation was treated as a separate research area of the project. Considering the rotable aerospace parts a market model was introduced to investigate the effects of adaption into turnover of part suppliers. Through the analysis, it is observed that blockchain reduces information asymmetry and the operational cost benefits of adaption are magnified by market effects. This way, blockchain introduces both economic and sustainability benefits.

The benefits of the project are generalizable for the medical, high-tech and other manufacturing sectors. The blockchain adaption is crucial in industry and ITOPP provides a blueprint approach for traceability blockchains.

CONTENT

"SHARING TRACEABILITY INFORMATION SAVES THE TIME, AND ULTIMATELY, THE MONEY REQUIRED TO COLLECT THAT INFORMATION YOURSELF."

REMCO DIJKMAN
TU/e

BACKGROUND

While traceability of parts and products is essential to be allowed to operate in regulated industries, it is beneficial for other industries as well. Tracing parts and product information from suppliers enables companies to easily verify that parts or products are of sufficient quality to be used. This is especially important when considering the general aim of reducing our footprint on natural resources by reusing (refurbished or re-manufactured) parts and products; if companies can easily establish that used parts or products have been produced and maintained according to quality standards and regulations, they will be more inclined to reuse them. Traceability also helps to efficiently handle service requests from customers, because it creates a record of the parts of a product that is owned by a customer, enabling the company to easily determine which parts must be serviced in which manner. This is especially important for recall actions, which require that a company is aware of the customers who own defective products or parts of products.

Blockchain enables sharing of individual data among participant organizations. This provides further opportunities by using supply chain analytics. The history and ownership of data is established in the blockchain. The organizations will have the ability to utilize trusted data to further increase effectiveness of operations and provide added value. The digital ledger technology and consortium blockchains also enable participation of authorized actors.

CHALLENGE

The primary goal of the project is to develop a generic infrastructure for traceability of parts and products, which demonstrably reduces the time associated with quality and regulatory checks, increases reuse of parts and products and reduces their total cost of ownership. To achieve this goal, the following subgoals must be met.

First, the requirements for traceability of parts and products must be determined.
These requirements consist of:

- The purposes with which traceability is done by companies.
- The activities that must be registered for these purposes along with the information that must be kept of those activities.
- The analyses tasks that must be performed for these purposes.

Second, an infrastructure is developed that meets these requirements. This infrastructure consists of a technical platform that supports the registration and analysis tasks and governance controls and procedures that ensure reliability and trust on the technical platform. BlockChain is used as candidate technology for the technical platform, because its distributed nature matches the distributed nature of traceability of parts and products between different parties and because it helps to ensure trust between those parties on a technological level. Third, a demonstrator is developed on two levels. The first level is a generic platform for traceability of parts and products that is made publicly available. The second level is a specific implementation of that platform at one of the partner companies of the project. With this implementation, the effect of the infrastructure on total cost of ownership reduction at the partner is measured and generalized to make an overall estimate of cost saving potential for the improved traceability platform.

PROJECT DESIGN

The development of the traceability platform was based on real-world traceability scenarios, for which software solutions were developed in an incremental manner. A generically usable version of the platform was developed that can be downloaded and tested by various organizations and a specific prototype of the platform was implemented in practice.

Fokker Services provided the traceability scenarios and was the partner at which the platform was implemented. IBM provided technical advice on the implementation of the platform and the Service Logistics Forum was dissemination partner. Louman Logistics, Ricoh, Districon, Nedtrain and GS1 were associated partners that kept were interested in the developments of the project and attended workshops.

1

USAGE SCENARIOS

This work package concerns the identification of the specific goals that must be achieved by the platform and the functionality that the platform must provide in order to achieve these goals. While the overall goal of the platform is clear – to reduce the costs and increase the speed of quality and regulatory checks, and to increase the number of parts that can be reused efficiently – this work package will determine specific goals by analyzing typical scenarios of parts and products traceability that can be supported by the platform.

2

GENERIC PLATFORM DEVELOPMENT

Work package 2 concerns the development of the generic platform. This includes an analysis of existing platforms and research on parts and products traceability, the identification of a scientific contribution within this area, and the actual development of the generic platform.

3

PLATFORM IMPLEMENTATION AND EVALUATION

Work package 3 concerns the implementation of the generic platform at the implementation partner and the evaluation of the potential effect that the platform can have within the implementation company. It also concerns at least two feasibility studies at associate partners, in which the potential of the platform in other industries is investigated. The findings from the implementation, evaluation and feasibility studies are generalized to evaluate the general potential of the platform

4

MANAGEMENT AND DISSEMINATION

This is a management work package. Objectives include management of project tasks, realization of deliverables, guaranteeing the scientific, non-scientific and administrative coordination of all activities of the project, ensuring quality, disseminate knowledge.

RESULTS

The project has both social and sector related results. The results of the project can be summarized for four topical areas and dissemination. Among the topics related to First is the analysis of the traceability process and the use cases of the software platform, second is the development of the traceability blockchain prototype and evaluation, third is the integration and evaluation of the prototype and valorization. The larger economic impact of the blockhain was seperately evalauated. In this study the market characteristics were modelled for aerospace rotable parts market and effect of blockchain adaptation on turnover of the firms were evaluated. Finally, the prototype was presented, made available through internet and the source code was made open.

The prototype software requirements were described in a study performed in Fokker Services. The process of formal traceability was described with the major actors, processes, data and documents. The process model with the software requirements were utilized as the basis for traceability blockchain. The process elements were transformed to smart contract transactions. The preconditions, constarints and operations are trasnformed to transaction code. By this way the blockchain enforces the rules and establishes the rights for each actor for parts and transactions.

Requirements of formal industries were taken into account during development of the blockchain. The current ERP is to be sychronised with interorganizational blockchain. Therefore the blockchain data is interlinked to ERP data by using a localID. This makes integration of organizations with traditional ERP systems to traceability blockchain with minimal effort.

One of the major advantages of blockchain is automated execution of payments. In the project, the payment period is established when a part is shipped to another organization and the period is started after the receiver receives and get ownership of the part The interorganizational establishment of part ownership enables trusted payment shared process.

The blockchain enables sharing of individual data among participant organizations as they will. This provides further opportunities by using supply chain analytics. The history and ownership of data is established in the blockchain. The organizations will have the ability to utilize trusted data to further increase effectiveness of operations and provide added value. The digital ledger technology and consortium blockchains also enable participation of authorized actors.

SOCIETAL RESULTS	
Potential cost efficiency	€50 per PO
Online available platform	1
Participants IToPP webinar	59
Follow-up collaborations	3

SECTOR RESULTS	
Involved/reached companies	9
Involved/reached SME company	1
Researchers/students now working at company	3

SCIENTIFIC OUTPUT	
Master theses	1
PostDocs	2
Scientific Working Papers	3
Scientific seminars, workshops, lectures, presentations etc.	2

The blockchain prototype was presented in various venues and got interest among other organizations. This venues include. The prototype was made available through www.itopp.nl. For interested parties the source code of the prototype was made available through github repository.

RESULTS TO BE PROUD OF

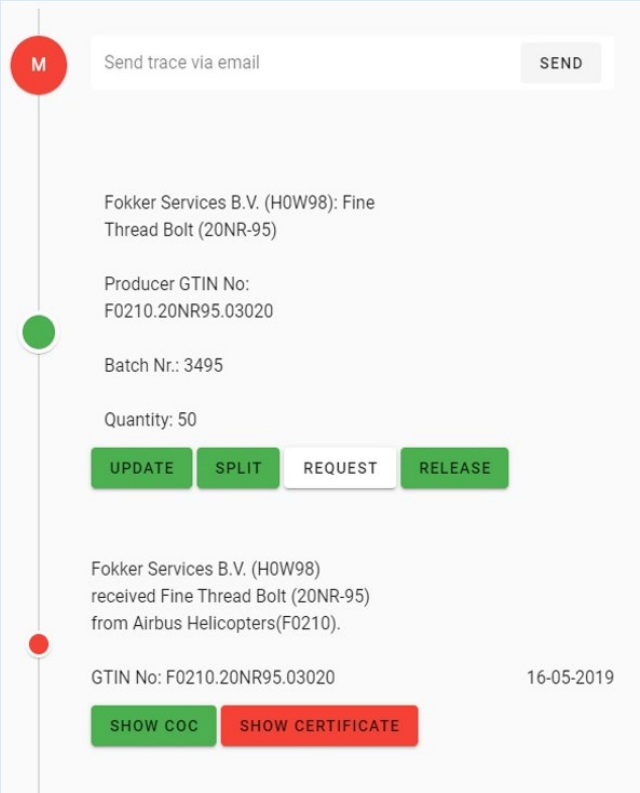
1. A TRACEABILITY BLOCKCHAIN PROTOTYPE IS DEVELOPED FOR TRUSTED BACK-TO-BIRTH TRACEABILITY OF PARTS AND PRODUCTS.
2. A GRAPHICAL USER INTERFACE (ITOPP.NL) AND WEB API IS DEVELOPED TO DEMONSTRATE THE PROTOTYPE TRACEABILITY BLOCKCHAIN
3. AN ECONOMIC IMPACT ANALYSIS OF BLOCKCHAIN ADOPTION FOR TRACEABILITY OF ROTABLE PARTS SHOWED THE POTENTIAL FOR COST REDUCTION.
4. A PRECISE MAPPING OF TRACEABILITY TASKS TO BLOCKCHAIN TRANSACTIONS IS MADE.
5. SEVERAL USE CASES OF A TRACEABILITY PLATFORM ARE DEFINED AND IMPLEMENTED, INCLUDING DISPUTE MANAGEMENT AND PAYMENT PROCESSING.
6. AN INTEGRATION BETWEEN ERP AND THE TRACEABILITY BLOCKCHAIN WAS ESTABLISHED SO THAT THE ERP DATA CAN BE TRANSFERRED TO THE BLOCKCHAIN AUTOMATICALLY.
7. SOFTWARE DESIGN REQUIREMENTS FOR TRACEABILITY IMPROVEMENT WERE FORMULATED.
8. THE TRACEABILITY BLOCKCHAIN PROTOTYPE WAS PRESENTED AT VARIOUS SCIENTIFIC AND INDUSTRIAL VENUES.
9. THE PLATFORM DOCUMENTATION, TRACEABILITY GUI AND SMART CONTRACT IS MADE AVAILABLE AS OPEN SOURCE FOR EASY EXPLORATION BY INTERESTED PARTIES.
10. THE PARTNERS OF THE PROJECT HAVE SHOWN THE POTENTIAL FOR LARGER SCALE DEVELOPMENT OF THE BLOCKCHAIN PLATFORM.

BLOCKCHAIN TRACEABILITY PLATFORM PROTOTYPE

Considering the traceability requirements in regulated industries, the consortium explored the traceability problem, defined use cases and developed a prototype traceability platform. This is to be used by supply chain actors in the industry. We also evaluate the foreseen efficiency benefits of the blockchain traceability platform compared to current practice. The development of the prototype is done in close collaboration with the implementation partner which is an aerospace service company.

The blockchain platform realized uses cases by providing one-click trace, consistent among actors, dispute management, access controlled trace data, ERP integration and automatic payment period upon delivery.

In the end the platform provides significant efficiency improvement as manual traceability data is replaced with blockchain data. The validity information is reused providing simpler and more efficient traceability for downstream actors. The additional advantages occur as the dispute resolution is streamlined, as the parties of a dispute will access to the unique consistent trace. Moreover, the task of going over a bunch of documents and/or files is eliminated. The trace data is validated by upstream actors or the actors having the same batch which is not possible in the traditional approach.



Trace Interface of the Traceability Platform.

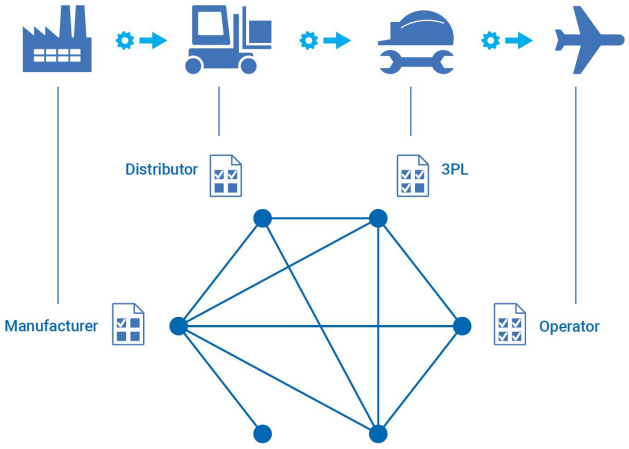
TRACEABILITY BLOCKCHAIN

Traceability blockchain is a consortium blockchain that forms the backbone of traceability platform. It is to be used by supply chain actors in manufacturing supply chains which are authorized to participate in the blockchain.

The blockchain guaarantees that trusted traceability data resides in the chain. This is performed via the smart contract transactions. Each smart contract has certain preconditions to guaraantee that the authorized actors are performing transactions on correct parts.

As part is created a corresponding part entry is created in the blockchain. The accumulated information on part updates (ship, attribute update, batch split, maintenance, use) and ownership changes are stored in the blockchain.

Hyperledger Fabric is used as the technology platform for the project.



Traceability Blockchain as a Source of Trusted Data.

EXPERIENCES

Each partner of the project has contributed in their own capacity and expertise for the success of the project, The traceability process of regulated industries were defined in close collaboration of implementation partner. Development and implementation partner define a generic process for improved traceability. IBM has contributed to provide information about usage of Blockhain in different domains and optimize the platform design. Development partner and SLF has contributed to present the work to greater audience in workshops.

OPEN INNOVATION

The main effort for open innovation was the open source publication of the developed protoype on GitHub as well as the publication of a running version of the prototype on itopp.nl. This publication is complemented by an API description, software documentation, and a tutorial that interested parties can use to develop their understanding of the platform.

DINALOG AND TOPSECTOR LOGISTICS

The project provided the partners better understanding of the blockchain technology. The partners also are more aware of the future challenges and opportunities of blockchain in logistic area.

The extensive knowledge of aerospace domain contributed to understanding of the traceability and other related processes. The research and development partner capability has resulted research output and traceability platform. IBM contributed to design consortium blockchain design. SLF provided feedback and relations with the logistic sector. The partners do have an understanding of the benefits of the blockchain for traceability and motivation to take further steps to adapt blockchain for traceability.

By achieving the results outlined above, the project directly contributed to the general aims of reducing the footprint on natural resources and realizing the circular economy as they are identified by the European Commission and the Dutch Organization for Scientific Research and supported by the Topsector Logistiek.

SOFTWARE DESIGN REQUIREMENTS FOR TRACEABILITY

We collaborated with Fokker Services to determine the software requirements for a platform for traceability of parts and products. The main goal was to understand what a company is really looking for in such a platform.

We collaborated with Fokker Services, together with a Master student and a Postdoc to map the requirements. This led to very precise insights into the day-to-day operations of a maintenance services provider, specifically as they relate to traceability.

As a result the operational processes and the related software requirements were mapped and at a later stage these were also linked to concrete Blockchain transactions. The results were published as a scientific paper. This collaboration clearly showed how case studies at a company can lead to generalizable scientific results.

Remco Dijkman – TU/e

TRACEABILITY OF AEROSPACE ROTABLE PARTS – FOKKER SERVICES

While traceability of parts and products is key to safety in the aerospace. The complete life cycle of a part is often not visible at any point in the supply chain. Companies downstream in the supply chain do not have an overview of the complete history of the part and companies upstream do not have an overview of the current status, owner or location of the part. To ensure traceability business-2-business, a less efficient manual process takes place at each company and to comply with authority regulations all to ensure traceability.

What if; we would have a place where every part has a trusted digital identity and historical record that is immediately accessible to those with the right credentials The IToPP project provided insights how such trusted digital identity could work in the Aerospace domain. And not only theoretically, the prototype gave us more insights on how this traceability could be visualized. Where in the last months of the project we also proven that a direct link with Fokker's ERP system that feeds into the blockchain prototype is achievable. Challenges can be found in the complex aerospace domain to keep the use cases simple and to the point, but not oversimplified and understanding that all the companies in this ecosystem have incentives to feed data into such platform.

Wouter van Dis – Fokker Services

The IToPP project gave Fokker Services a solid base to further develop the trusted digital identity for parts and products. The white paper 'Economic Impact of a Traceability Blockchain for Aerospace Rotable Part' that resulted out of this research program is giving Fokker Services enough foundation to believe companies that will embrace a traceability blockchain will economical benefit compared to those who don't. Fokker Services is in the position to discuss with other aerospace companies a traceability platform provide other companies with potential economical benefits and is able to show through the prototype functions that could be performed.

VISION OF THE FUTURE

The results of the project are mainly to be extended in two directions: within the aerospace parts supply chain and across other supply chains.

Within the aerospace parts supply chain, it will be important to involve companies from throughout the entire supply chain, including original equipment manufacturers, maintenance, repair and overhaul organizations, resellers, and operators. Only when all these partners contribute can true back-to-birth traceability be realized. While the project studied incentives to get these partners on board. These incentives can be studied in more detail and made specific for the different types of project partners.

Across supply chains, other supply chains in which Blockchain can help develop trust in product quality – through traceability – can be studied. This includes food supply chains, medical device supply chains, and fair-trade supply chains. Such studies require further generalization of the developed prototype to make it easy to use in other supply chains. It also requires market studies in these other supply chains.

FOLLOW UP ACTIVITIES

At this moment the blockchain prototype is implemented at a single partner. One of the continuing activities is implementing it in a consortium that involves the complete supply chain of that partner, to achieve the desired economies of scale and the critical level of Blockchain adoption at which the entire sector will start to benefit.

Another area of research is the scalability of Blockchain technology to make Blockchain effective for use in large scale consortiums. Investigation of alternative designs, including different transaction policies, as well as Blockchain and cloud technologies is valuable.

> “BLOCKCHAIN CAN FACILITATE TRUST IN MANY SUPPLY CHAINS IN WHICH THAT IS IMPORTANT IT CAN FACILITATE TRUST IN PRODUCT QUALITY, TRUST IN INFORMATION RELIABILITY, AND TRUST IN A CONTROL STAMP.”

PROJECT PARTNERS

ITOPP involved Eindhoven University of Technology as research and development partner, IBM as technology partner, Fokker as implementation partner, and the Service Logistics Forum (SLF) as dissemination partner.

PUBLIC PARTNERS

FOKKER SERVICES

Fokker has a long history in aerospace engineering and in particular with maintaining aircraft and aircraft components. In this domain, parts and products traceability is an important concern. With this background Fokker provided the consortium with domain knowledge on parts and product traceability and the specific challenges with respect to parts and product traceability in aerospace engineering. The ERP data was also supplied for the traceability blockchain.

IBM

IBM has extensive experience in the area of software development, requirements analysis, development ofbusiness cases, and software integration. IBM has a software development departmen tthat specializes in Blockchain. During the project, IBM worked in the use cases of the blockchain and technical feasiblity.

SLF

The Service Logistics Forum is a network organization of companies interested inservice logistics. They enable companies to learn about service logistics from eachother and from knowledge organizations. As such they facilitated the dissemination of knowledge that is developed within the project in their network.

PRIVATE PARTNERS

TU/E

Eindhoven University of Technology has a strongtrack record in both research and development of information platforms and product lifecycle and spare parts management. In this project, Eindhoven University of Technology was responsible for research activities, requirements analysis, prototype software development and project management.

AUGUST 2021

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Topsector Logistiek

TKI Dinalog is the Topconsortium Knowledge and Innovation of the Topsector Logistics