overcome IPR barriers to enter the mainstream manufacturing realm, supporting OEMs to preserve IPR in sharing spare part 3D designs with AM service providers or end customers. By searching for a solution to this practical design problem [1](how OEMs using DM service providers can protect their IPR), we investigate the theoretical problem of facilitating decentralized manufacturing through AM technology while maintaining a competitive advantage using digitally traceable IPR.

During three months of close collaboration, a deep-tech startup, information technology (IT) service management company, and university developed the proposed digital tool, which can be characterized as an ensemble artifact [2], supporting the required technical rigor and practical relevance. Accordingly, this arrangement perfectly aligns with an action design research (ADR) project based on design science principles [2]. According to the ADR methodology stages, the proposed digital tool and its design process are described in the following sections [2].

1.1 Problem F[2].

1.2 Building, Intervention, and Evaluation

The problem owners (deep-tech company representatives) met weekly throughout the project with the researchers and technical solution developers (software engineers from the IT service management company), resulting in several iterative artifact development cycles. The prototype originated from the concept of blockchain technology, more precisely NFTs.

An NFT is a digital asset including \a non-interchangeable unit of data stored on a blockchain," which is \a form of digital ledger that can be traded," frequently online with cryptocurrency [5]. The NFTs are uniquely identi able, and the creator can easily prove their existence and ownership via a unique digital certi cate [5]. They represent real-world objects, such as art, collectibles, music, in-game items, videos, and some versions of 3D les [5]. The NFTs are a promising solution for IPR protection due to their \convenient interoperability, full-history tradability, and deep liquidity" [5].

The industrial partner's problem was twofold. First, the company needed to keep the industrial design of the sensor enclosure guarded against third-party exploitation and counterfeiting because of signal noise barriers they created and smart distancing between the novel ultraviolet sensor and the circuit board. Second, the company needed to provide the customized 3D design to clients and facilitate the sale of the sensor package without committing to in-house production and allowing the use of third-party AM service providers.

Using NFTs, we introduced an intervention into the traditional design-sharing process to assist with protecting 3D design IPR while unlocking the possibility to take full advantage of AM capabilities, including decentralized production (Fig. 1). The prototype we present in this paper was created by combining Web 3.0 technology and robotic process automation (RPA) to facilitate minting NFTs. We used the OpenSea platform for NFTs, which currently is the largest NFT trading marketplace by turnover [5].

The prototype was created in two phases. First, the development e orts were focused on automating the process of NFT minting on the OpenSea platform. Since the OpenSea platform lacks publicly available support for direct machine-to-machine interaction with their platform, we applied RPA technology, which enables the automatic execution of work ows through user interfaces originally designed for human interaction. In the prototype, the RPA solution controls a web browser window and directly interacts with the OpenSea website, automatically completing web forms and collecting data from the OpenSea website. With the RPA process successfully implemented and thoroughly tested in the second phase, the development e orts turned to creating a web-based user interface.

4 Evaluation of the Artifact

Currently, the proposed prototype is entering eld testing parallel to the nalization of this paper. Based on the deep-tech company's evaluation, NFTs are among the few blockchain-based technological solutions they examined to create trust between the stakeholders while enhancing exibility and e ciency in the production operations. According to the CEO,

\The prototype allows us to reach a larger customer base and potentially higher sales by enabling us to quickly bring the products from design to the [online] market without IP concerns. This can be translated to a competitive advantage for our company. Moreover, it has the potential to complement and gradually replace the legal frameworks for IP protection in the context of manufacturing."

Furthermore, the deep-tech company noted that the following eld improvements are required. First, traditional legal procedures are not up to the task and must catch up with the current digital transformation. Additionally, smart contracts enabled by blockchain technology are not yet equally legally binding as non-disclosure agreements and sales contracts. For the full potential of NFTs, smart contracts should be admissible in court. Second, technologies that can create an interface between the data transfer and production platforms (e.g., AM machines) must be improved. This interface can facilitate transactions between OEMs, end customers, and production facilities. Currently, the data interface between the NFT hosting platform and AM machines is non-existent. Third, the prototype faces a limitation imposed by the NFT minting platforms (e.g., OpenSea) that still do not support a wide range of 3D design le formats, which can easily change as the NFT minting platforms mature.

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