Digital Transformation of Traditional Art: From 3D Scanning to Casting and Additive Manufacturing

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ABSTRACT

This poster demonstrates the high-fidelity digital transformation of traditional sculptures using HandySCAN 3D scanning technology. Optical reference markers were applied to a physical statue to enable accurate dynamic referencing and capture sub-millimeter surface details. The acquired point cloud was processed into a high-resolution 3D mesh and further optimized for downstream manufacturing applications. Two complementary routes were demonstrated: an industrial casting path using the scanned model as a basis for mold preparation and metal casting, and a prototyping path involving slicing, support generation, and FDM 3D printing at reduced scale. The study highlights how reverse engineering and additive manufacturing can bridge classical craftsmanship with modern digital documentation, replication, and sustainable production workflows.

INTRODUCTION

The digital transformation of traditional sculptures increasingly relies on optical 3D metrology to document, reconstruct, and reproduce complex freeform geometries with high dimensional fidelity. Conventional manual measurement techniques are limited in capturing organic surfaces, fine relief details, undercuts, and sculptural features without compromising efficiency or accuracy. In this study, a physical statue was digitized using the HandySCAN BLACK™ | Elite Limited, a metrology-grade handheld blue-laser 3D scanner. By applying optical reference markers for dynamic referencing, dense surface data were acquired and converted into a high-resolution polygon mesh. The scan data was further processed within the Creaform Scan-to-CAD/VXmodel environment through mesh alignment, cleaning, hole filling, decimation, and watertight STL preparation for downstream manufacturing.

HandySCAN BLACK | Elite Limited

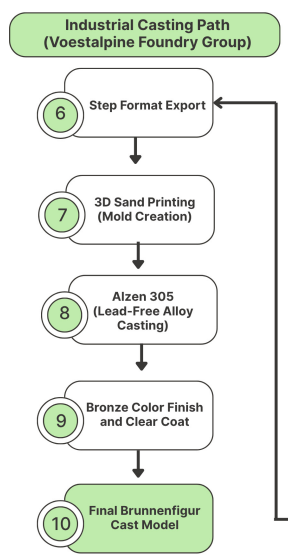
FARO | CREAFORM

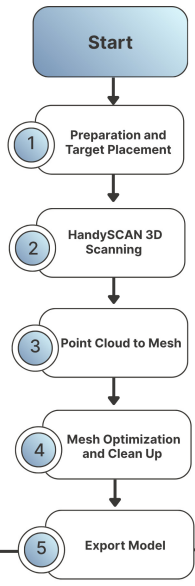
AMETEK

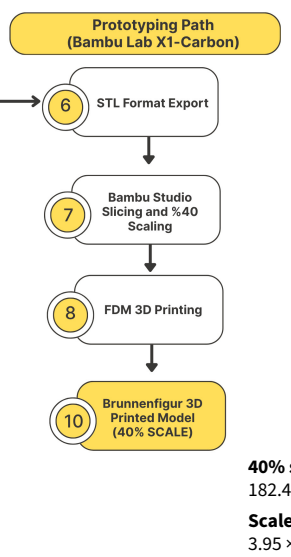
Original dimensions:
456.1 × 157.2 × 697.1 mm

Digital model volume:
6.17×10^6 mm^3

The project utilizes the HandySCAN BLACK™ | Elite Limited, delivering an industry leading accuracy of 0.012 mm. This metrology grade system ensures high-resolution data capture with a measurement rate of 1,300,000 measurements/s, bridging the gap between physical art and precise digital twins.







40% scaled model:
182.4 × 62.9 × 278.8 mm

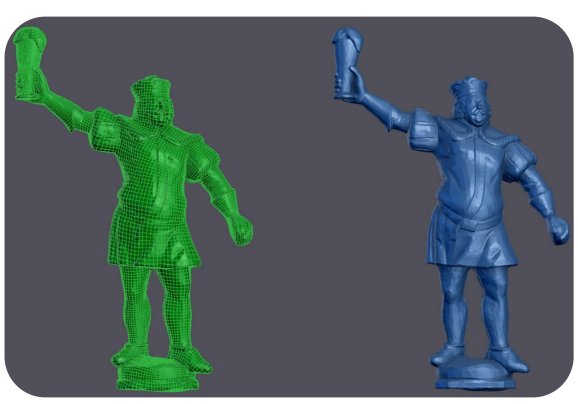
Scaled model volume:
3.95×10^5 mm^3

The optimized digital model, derived from an original Brunnenfigur measuring 456.1 × 157.2 × 697.1 mm with a digital model volume of 6.17×10^6 mm^3, was subsequently used as a manufacturing-ready master geometry for two complementary process chains. In the industrial casting route, the reconstructed 3D model supported mold preparation and the production of a metal replica using Alzen 305, a lead-free ZnAlCu alloy developed for demanding casting and tribological applications. In the prototyping route, the model was scaled, sliced in Bambu Studio, equipped with support structures for overhanging regions, and fabricated using a Bambu Lab X1-Carbon FDM system. By integrating optical metrology, reverse engineering, mesh optimization, casting, and additive manufacturing, this work demonstrates a complete workflow from cultural object digitization to accurate physical reproduction.

1 ACCURATE COORDINATE SYSTEM AND VOLUMETRIC PRECISION

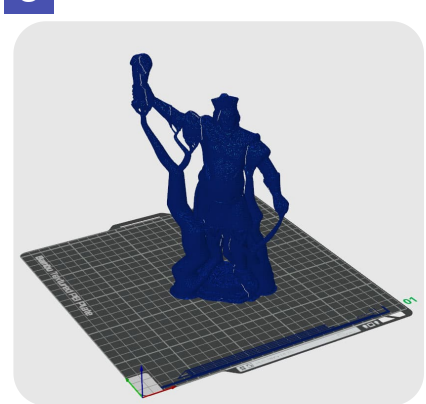
Reference coordinate targets are meticulously applied to the complex geometry of the statue, ensuring volumetric precision and absolute geometric accuracy for a watertight mesh.

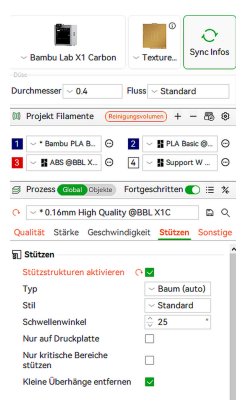
2 HIGH-RESOLUTION DATA CAPTURE



Point Cloud to Mesh (0.1 mm) Capturing millions of surface points and filtering noise to generate a high-density, accurate 3D mesh with 0.100 mm resolution. The workflow utilizes the Creaform Metrology Suite and its Scan-to-CAD module (VXmodel) to process the raw data and successfully generate a high-fidelity STL model for the subsequent physical replication steps.

3 CONSTRUCTION OF SUPPORT ELEMENT AND SLICING

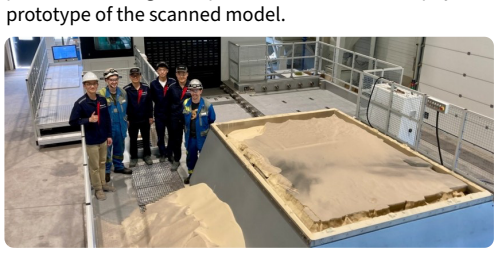




Tree support structures were generated with a 25° overhang threshold to ensure print stability while preserving fine geometric details. Slicing was performed using a 0.16 mm layer height.

INDUSTRIAL CASTING PATH

The controlled casting operation of Alzen 305 alloy is performed at high temperatures to realize the physical prototype of the scanned model.



The large-scale sand mold preparation and field application demonstrate the industrial-grade manufacturing process based on digitized 3D data.

The final product showcases a high-precision bronze reproduction, scaled to 40%, achieved through reverse engineering and advanced 3D scanning workflows.

alzen® 305
White bronze alloy without lea with reduced CO_2-footprint

voestalpine
ONE STEP AHEAD.

PROTOTYPING PATH

The scanned model was scaled to 40% of the original size, resulting in final model dimensions of 182.4 × 62.9 × 278.8 mm, before being fabricated using FDM 3D printing.

The completed 40%-scale physical replica demonstrates the successful integration of reverse engineering, digital model preparation, and additive manufacturing with high geometric accuracy.

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