Innovative Technology Research and Selection

To bridge the gap between high-precision heritage preservation and engaging digital storytelling, we have researched and selected a suite of technologies derived from the gaming, film, and geodetic industries. This "tech stack" ensures that the transition from physical monument to digital twin is both scientifically accurate and visually captivating.

Below is the proposed selection of hardware and software solutions categorized by their role in the reconstruction pipeline.

1. High-Precision Data Acquisition (Hardware)

The quality of a digital reconstruction is only as good as its source data. We utilize a multi-layered approach to capture every angle of a heritage site.

- **Aerial Capture (Drones):** Selected for covering large-scale surfaces and inaccessible areas (e.g., rooftops, towers). Drones provide the optimal geometry required for large-scale 3D photogrammetric reconstruction.
- **Field Capture (Mirrorless Cameras):** Used for high-resolution terrestrial photography. These capture fine architectural details—such as window sills, bridges, and eaves—that drones often miss, ensuring rich textures and sharp geometry.
- **Spatial Context (360° Cameras):** Provides a rapid spherical capture of interior spaces, offering vital visual reference data and immediate spatial context for the digital team.
- **Geodetic Precision (Theodolite & GCP Markers):** To move beyond "visual models" into "measurable models," we use a theodolite to measure **Ground Control Points (GCPs)**. These markers allow for absolute measurement accuracy and the precise geopositioning of the object within global coordinates.

2. Advanced Processing & Optimization (Software)

Before entering a game engine, raw data must be cleaned, aligned, and optimized.

- **Agisoft Metashape (Photogrammetry):** Our primary reconstruction engine. It was chosen for its granular control over 3D model generation, advanced alignment settings, and the ability to manually correct markers against geodetic data (GCPs), ensuring the highest level of scientific accuracy.

- **Adobe Lightroom:** A critical pre-processing tool used to correct color, exposure, and lens distortion. High-quality input data significantly reduces errors during the photogrammetric reconstruction phase.
- **Insta360 Stitch:** Specialized software for "stitching" 360° captures into seamless, high-quality panoramas, maintaining visual uniformity across interior tours.

3. Gaming & Film Industry Engines (Modeling & Simulation)

This is where heritage recreation meets modern interpretation. We utilize tools standard in Hollywood and AAA gaming to ensure the assets are "future-proof."

- **Blender 3D:** The industry-leading open-source tool for 3D modeling, retopology, and animation. We use Blender to "clean" the raw scans, optimize geometry for web use, and prepare historical reconstructions (recreating missing parts of buildings).
- **Unreal Engine / Unity:** These world-class game engines are used for real-time, photorealistic visualization. They allow for **Physically Based Rendering (PBR)**, advanced real-time lighting (Global Illumination), and the creation of interactive VR/AR applications. This transforms a static model into an immersive environment where visitors can "walk" through history.

4. Interactive Dissemination & Knowledge Transfer

To ensure the heritage is accessible to the public, the final models are hosted on user-friendly platforms.

- **3D Heritage portal:** 3D Heritage collects, presents, shares and interprets cultural heritage – through detailed, accurate and photorealistic 3D models, 360-degree photos and other audio-visual media our common roots will digitally come to life. Its own 3D viewer enables anyone to quickly and easily inspect and measure digitally captured monuments, while its reliable and safe data center digitally preserves the cultural heritage of humanity.
- **Vista3D:** A specialized application for creating interactive panoramic virtual tours. This enables the final 360° spatial data to be published online, allowing global audiences to explore Montenegro’s heritage sites through any web browser.